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CATEGORY II F-111A RELIABILITY AND MAINTAINABILITY EVALUATION

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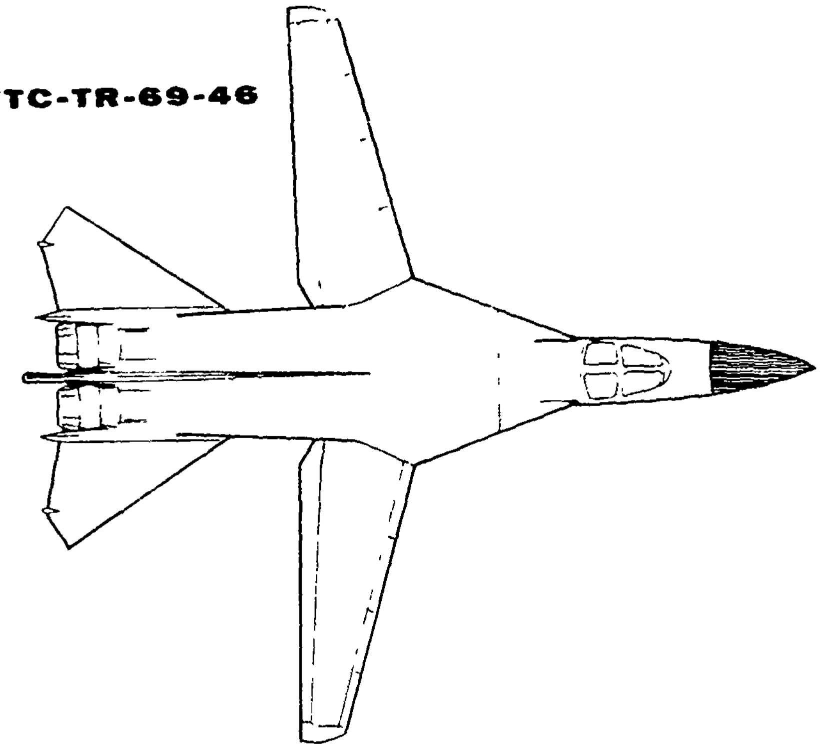

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FOREWORD

The F-111A Category II Reliability and Maintainability Evaluation program was initiated and conducted as part of the Category II flight testing of the F-111A. The F-111A Category II flight test program was initiated by Air Force Flight Test Center Project Directive 62-69C, dated 15 July 1964, with an Air Force Systems Command priority of 02. The flying portion of this program was accomplished between 15 January 1966 and 31 October 1969.

Data was accumulated and analyzed using the Systems Effectiveness Data System which was developed by the TRW Systems Group, Redondo Beach, California, for the Space and Missile System Organization of the Air Force Systems Command, Los Angeles Air Force Station, California, under contract No. F-04701-68-C-0172.

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ABSTRACT

This report presents a reliability and maintainability analysis resulting from the F-111A Category II testing at Edwards Air Force Base. During Category II testing the F-111A flew 2,019 hours, generating approximately 31,000 reliability and maintainability data records. The majority of Category II tests were flown on preproduction aircraft; however, several production aircraft were tested in the last year of the program. The data in this report covered only the last 22-month period so that the analysis would be more representative of production aircraft. The analysis utilized 1,240 of the flying hours and approximately 18,000 of the data records. The F-111A had a measured reliability of 0.83 probability of mission success during Category II testing. The contractor specified reliability was 0.85 probability of mission success. Missions which might have been aborted in an operational environment were considered successes at Edwards when part of the planned mission test objectives were met. Therefore, the 0.83 probability of mission success may be misleading. The measured mean times between failures (MTBF's) on the lead computing optical sight and the UHF communications, which were government furnished equipment, met the contract end item (CEI) specified MTBF's. All other avionic subsystems were below the CEI specified MTBF's except for the Countermeasures Receiver Set and Radar Homing and Warning System which had insufficient testing time to determine an MTBF. The maintainability analysis showed that it took more man-hours to maintain the aircraft than had been predicted by the contractor. The measured maintenance man-hours per flying hour for the F-111A during Category II testing was 82.3 hours as compared to the contract specification of 35. The subsystems that failed to meet the contractor's predicted values by a large margin were the same subsystems that had the low reliability figures. The maintainability of the aircraft was generally good, but the low reliability of some of the avionic subsystems and the propulsion subsystem caused a high maintenance man-hour per flying hour figure.

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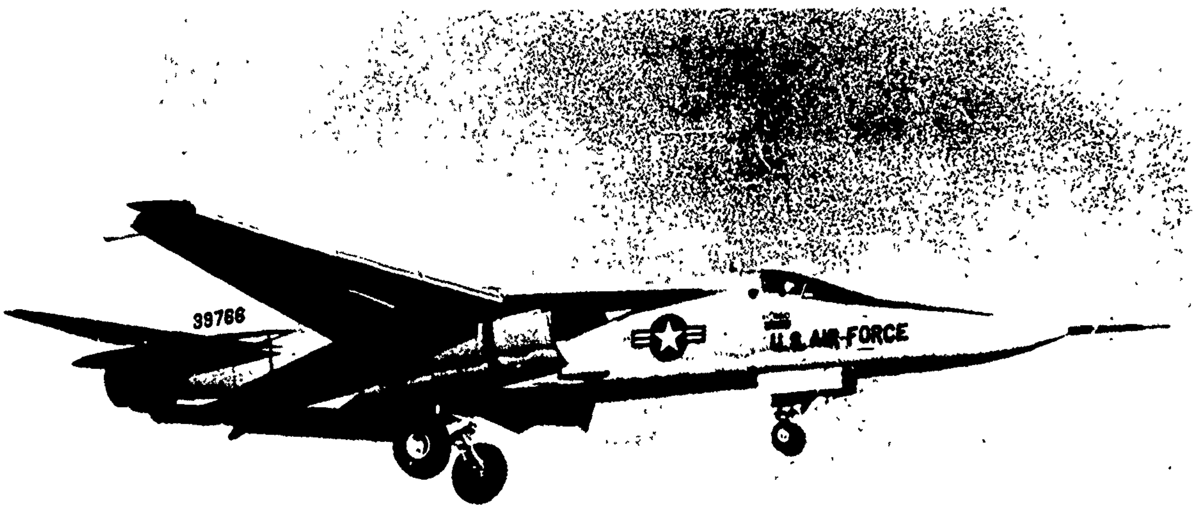
List of Abbreviations and Symbols

Item	Definition
acft	aircraft
ADF	Automatic Direction Finding
CEI	contract end item
CMRS	Counter Measures Receiver Set
Comm	Communcications
Cond	Conditioning
ECM	Electronic Counter Measures
F( )	probability density function
GND	ground
HF	high-frequency
Hyd	hydraulic
IFF/SIF	Identification Friend or Foe/Selective Identification Feature
ILAS	Instrument Landing Approach System
LCOS	Lead Computing Optical Sight
Misc	miscellaneous
M_{max}	probability density function value at probability 0.9
MMH/FH	Maintenance man-hours per flying hour
MTBA	mean time between aborts
MTBD	mean time between discrepancies
MTBF	mean time between failures
N	sample size
N_a	number of abort failures
N_d	number of degraded operations
N_f	number of no-abort failures
N_s	number of success
Nav	navigation
P	lower confidence limit probability
P_{na}	probability of no abort
P_{nd}	probability of no discrepancy
Pneum	pneumatic
P_{nf}	probability of no failure

Item	Definition
Press	Pressurization
PWR	power
R	number of failures accumulated
RHAWS	Radar Homing and Warning System
T	total system operating time
TFR	Terrain Following Radar
UHF	ultra-high frequency
WUC	work unit code
α	acceptable risk or error
$1 - \alpha$	confidence level
μ, σ^2	log-normal probability distribution parameters
χ^2	chi-square probability distribution
θ	exponential probability distribution parameter
θ_1, θ_2	Weibull probability distribution parameters



INTRODUCTION

This report presents the results of the Category II Systems Reliability and Maintainability Evaluation of the F-111A aircraft. The evaluation was conducted by personnel of the F-111 Joint Test Force (JTF) at the Air Force Flight Test Center, Edwards AFB, California. Technical reports on other aspects of the F-111A test program are listed in the Bibliography.

The flight test program began on 15 January 1966, with the delivery of F-111A aircraft No. 8. By 31 October 1969, the F-111A Category II test aircraft had flown 1,044 missions for a total of 2,019 hours. The Systems Effectiveness Data System (SEDS) was used to store, retrieve, and analyze the reliability and maintainability data during the course of the F-111A Category II test program. The data collected on the F-111A was used to develop and test the computer programs generated under the SEDS contract.

The aircraft subsystems were tested in as nearly an operational environment as possible. The peculiarities of a testing environment were eliminated or accounted for whenever possible. The aircraft possessed during the Category II test program were not production aircraft, except aircraft used for short periods during the latter part of the test program. So that the analysis would be more representative of production aircraft, the data base on which this report is based began in January 1968. In the period 1 January 1968 through 31 October 1969, the F-111A flew 646 missions for a total of 1,140 hours.

Table I, Aircraft Utilization, contains a summary of missions flown during the Category II testing period 15 January 1966 through 31 October 1969.

DATA COLLECTION

Two sources of data were used as a basis for reliability and maintainability analysis. The first source used was hardware information recorded by maintenance personnel on the Maintenance Discrepancy/Production Credit Record, AFSC Form 258/258-4, (figure 1). This data source was known as the 258 Data System. This form was used for recording all maintenance actions in place of the standard AF Form 349/350. The reason for this was that the AF Form 349/350 did not have WHEN DISCOVERED TIME (Block 7, figure 1), and DELAY CODE (Blocks 34 and 37). Also missing on the AF Form 349/350 were personnel data by AFSC Code, Technical Order and Aerospace Ground Equipment (AGE) data. The when discovered time was necessary for accurate calculation of time between failures and time to maintain the systems. Without a delay code, the cause of work stoppage could not be identified; hence, time to maintain the system could not be accurately assessed.

The second source of data was operational information recorded on AFFTC Form 0294 (figure 2). This form was used to record aircrew analysis of system mission reliability after each mission and to summarize the maintenance actions required to clear the flight discrepancies.

Form Approved
Budget Bureau No. 21–R251

№ 458500

2 REPORT NUMBER

3 BASIC WORK CENTER | 4 ITEM IDENTIFICATION | 5 SERIAL NUMBER | 7 WHEN DISCOVERED TIME (Day-Mo-Yr-Hours)

8 DATE THIS REPORT (Day-Mo-Yr) | 9 WORK ORDER NUMBER

FAILED ITEM

14 MANUFACTURER | 15 MDS ENGINE TYPE MODEL SERIES MDS | 16 SERIAL NUMBER | 17 TIME CYCLES/MILES | 18 PART NUMBER

19. WORK UNIT CODE | 20. SYMBOL | 21. HOW MAL | 22 FEDERAL SUPPLY CLASS | 23 | 24

INSTALLED ITEM

25. MANUFACTURER | 26. MDS - ENGINE TYPE MODEL SERIES MDS | 27. SERIAL NUMBER | 28. TIME CYCLES/MILES | 29. PART NUMBER

SUPPLY DOCUMENT NUMBER (Issue or Demand) | 30. DESCRIPTION OF DISCREPANCY OR MAINTENANCE REQUIRED

H DISCOVERED BY

AFSC | 32. START | 33. STOP | 34 DELAY CODE | 35 START | 36. STOP | 37. DELAY CODE | 38. WORK UNIT CODE | 39. ASSISTING WORK CENTER | 40 UNITS | 41. ACT

42. T O NUMBER | 43. T O DATE (Day-Mo-Yr) | 44. T O PROCEDURE | 45. TOOLS/AGE | I CORRECTED BY

46. CORRECTIVE ACTION

J INSPECTED BY

K SUPERVISOR | L RECORDS ACTIONS | M DATE TRANSCRIBED (Day-Mo-Yr) | N TRANSCRIBED BY

UNCLEAR DISCREPANCY

REPLACEMENT TIME CHANGE

DATA TRANSCRIBED TO RECORDS

AFSC FORM JAN 66 258 PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE MAINTENANCE DISCREPANCY/PRODUCTION CREDIT RECORD

Figure 1 SAMPLE AFSC FORM 258 MAINTENANCE DISCREPANCY/PRODUCTION CREDIT RECORD (Front side)

47. PIECE PARTS REPLACED DURING REPAIR

	PART NUMBER	NOUN	WORK UNIT CODE	CIRCUIT SYMBOL	TYPE FAILURE PRI	TYPE FAILURE SEC	QTY	HOW MAL	MANUFACTURER	FSC
70										
T										
H R										
U										
79										

CODING TO BE IN BLOCKS AS INDICATED

BLOCK 34 AND 37 DELAY CODES

- S AWAITING SUPPLIES AND/OR PARTS
- C DELAY DUE TO CONFLICTING MAINTENANCE
- A WORK STOPPAGE – NON-POWERED AGE OR RPIE
- E WORK STOPPAGE – POWERED AGE OR RPIE
- F FLYING
- P AWAITING PERSONNEL ASSISTANCE
- R ENGINE RUN-UP
- T AWAITING TRANSPORTATION
- X DELAY FOR WEATHER
- K DELAY FOR SPECIAL TEST EQUIPMENT
- M PREPLANNED MAINTENANCE DELAY

BLOCK 41 ACTION CODES

1. SERVICING
2. UNSCHEDULED MAINTENANCE
3. PREFLIGHT INSPECTION
4. POSTFLIGHT INSPECTION
5. HOURLY POSTFLIGHT
6. PERIODIC INSPECTION
7. SPECIAL INSPECTION
8. INDEPENDENT
9. RESEARCH AND DEVELOPMENT

BLOCK 44 T O PROCEDURE CODES

1. ADEQUATE
2. INADEQUATE
3. INCOMPLETE
4. MISIDENTIFIED
5. NOT AVAILABLE
6. INCORRECT INFORMATION
7. OTHER

BLOCK 45 TOOLS AGE CODE

1. TOOLS ADEQUATE
2. TOOLS INADEQUATE
3. TOOLS NOT AVAILABLE
4. TEST EQUIPMENT ADEQUATE
5. TEST EQUIPMENT INADEQUATE
6. TEST EQUIPMENT NOT AVAILABLE
7. TOOLS AND TEST EQUIPMENT ADEQUATE
8. TOOLS AND TEST EQUIPMENT INADEQUATE
9. TOOLS AND TEST EQUIPMENT NOT AVAILABLE

* GPO 1966 O—799-591 AFSC (AAFB)

Figure 1 SAMPLE AFSC FORM 258 MAINTENANCE DISCREPANCY/PRODUCTION CREDIT RECORD (Back side)

F-111A DEBRIEFING RECORD

CARD NO	1 AIRCRAFT TYPE	2 ID SERIAL NO	3 MISSION NO	4 DATE DAY MONTH YEAR	5 T O TIME HOUR MIN	6 DURATION HOUR MIN	7 TYPE MISSION	8 MSN EFFECT	9 LAND MSS
1	F 1 1 1 A	A							
	10 HIGH MACH .	11 HIGH ALT .	12 AIR REFUEL THRU LB TRANS .	13 A'BORNE FUEL CON TACTS	14 SUPER TIME HR MIN	15 WING SWEEPS	16 O.S.M BELOW 1000 HOUR MIN	17	
	18 AIRCRAFT COMMANDER		19 PILOT/SYSTEMS OPERATOR			20			

CARD NO.	BLOCK NO	REL CODE	SYSTEM NAME	CARD NO	BLOCK NO	REL CODE	SYSTEM NAME
2	21		AIRFRAME	2	51		INERTIAL NAVIGATION
	22				52		ATTACK RADAR
	23		LANDING GEAR		53		RADAR ALTIMETER
	24		FLIGHT CONTROL		54		T F R
	25		ESCAPE CAPSULE		55		L C O S
	26		TURBO-JET ENGINE		56		DUAL INDICATING BOMB TIMER
	27		AIR CONDITIONING & PRESSURIZATION		57		
	28		ELECTRICAL POWER		58		
	29		LIGHTING SYSTEM		59		WEAPONS BAY GUN
	30		HYDRAULIC & PNEUMATIC POWER		60		PYLONS
	31		FUEL		61		WEAPONS BAY
	32		AIR REFUELING		62		WEAPONS CONTROL
	33				63		WEAPONS RACKS
	34		OXYGEN SYSTEM		64		
	35		MISCELLANEOUS UTILITIES		65		TRACK BREAKER SYSTEM
	36		INSTRUMENTS		66		C M R S
	37				67		C M O S
	38		AUTO PILOT		68		RHAWS
	39		AIR DATA		69		
	40		H F COMMUNICATIONS		70		
	41		U H F COMMUNICATIONS		71		
	42		INTERPHONE		72		
	43		IFF/SIF		73		
	44		MISCELLANEOUS COMMUNICATION EQUIPMENT		74		INSTRUMENTATION
	45		T A C A N		75		
	46		I L A S		76		
	47		U H F/A D F		77		
	48				78		
	49				79		
	50				80		

MISSION OBJECTIVES	% SUCCESS

SIGNATURE OF AIRCRAFT COMMANDER	SIGNATURE OF DEBRIEFER

CODE FOR BLOCKS AS INDICATED

BLOCK 7 (TYPE MISSION)	BLOCK 8 (MISSION EFFECTIVENESS)	RELIABILITY CODES
01 TRANSITION OR TRAINING	1 FLOWN AS BRIEFED	BLANK EQUIPMENT NOT USED
02 TEST SUPPORT	2 MISSION DEVIATION	1 OPERATED SATISFACTORILY
03 OTHER SUPPORT	3 AIR ABORT	2 DEGRADED OPERATION
04 SYSTEMS TEST	4 GROUND ABORT	3 FAILED BUT NO ABORT
05 PERFORMANCE TEST	5 FLOWN AS BRIEFED & ADDITIONAL EVALUATION PERFORMED	4 FAILED AND ABORT
06 STABILITY AND CONTROL TEST	NOTE: MISSIONS CHANGED FOR OTHER THAN MAINTENANCE ARE CODED 1	5 FLOWN WITH KNOWN DISCREPANCY

AFFTC FORM MAY 68 0-294

Figure 2 SAMPLE AFFTC FORM 0-294 F-111A MISSION DEBRIEFING RECORD (Front side)

DISCREPANCIES [1]

CARD	BLOCK	REL CODE	JOB CONTROL NUMBER	WHEN DISC	WORK UNIT CODE	HOW MAL	ACTION	POSITION	BITE	
3										

DESCRIPTION OF DISCREPANCY

CARD	BLOCK	REL CODE	JOB CONTROL NUMBER	WHEN DISC	WORK UNIT CODE	HOW MAL	ACTION	POSITION	BITE	
3										

DESCRIPTION OF DISCREPANCY

CARD	BLOCK	REL CODE	JOB CONTROL NUMBER	WHEN DISC	WORK UNIT CODE	HOW MAL	ACTION	POSITION	BITE	
3										

DESCRIPTION OF DISCREPANCY

CARD	BLOCK	REL CODE	JOB CONTROL NUMBER	WHEN DISC	WORK UNIT CODE	HOW MAL	ACTION	POSITION	BITE	
3										

DESCRIPTION OF DISCREPANCY

CARD	BLOCK	REL CODE	JOB CONTROL NUMBER	WHEN DISC	WORK UNIT CODE	HOW MAL	ACTION	POSITION	BITE	
3										

DESCRIPTION OF DISCREPANCY

CARD	BLOCK	REL CODE	JOB CONTROL NUMBER	WHEN DISC	WORK UNIT CODE	HOW MAL	ACTION	POSITION	BITE	
3										

DESCRIPTION OF DISCREPANCY

CARD	BLOCK	REL CODE	JOB CONTROL NUMBER	WHEN DISC	WORK UNIT CODE	HOW MAL	ACTION	POSITION	BITE	
3										

DESCRIPTION OF DISCREPANCY

CARD	BLOCK	REL CODE	JOB CONTROL NUMBER	WHEN DISC	WORK UNIT CODE	HOW MAL	ACTION	POSITION	BITE	
3										

DESCRIPTION OF DISCREPANCY

[1] *NOTE*

a Obtain Block Number from front of this form

b Obtain Job Control Number When Discovered Code, Work Unit Code How Malfunctioned Code and Action Taken Code from AFSC Form 258 AFTO Form 349 as applicable which shows the primary cause of failure

Figure 2 SAMPLE AFFTC FORM 0-294 F-111A MISSION DEBRIEFING RECORD (Back side)

The System Effectiveness Data System (SEDS) consisted of a series of programs employed to store, retrieve, and analyze the data contained on the AFSC Forms 258/258-4 and AFFTC Forms 0-294. The data collected from the forms constituted the SEDS Data Base from which all data products contained in this report were derived.

The basic philosophy of SEDS was to portray as realistically as possible the demonstrated reliability and maintainability of the F-111A weapons system. The effects of maintenance management, supply, and research and development functions were eliminated whenever possible.

258 DATA SYSTEM

Maintenance data collection for the F-111A Category II testing was an AFSC adaptation of the procedures outlined in AFM 66-1, reference 1. The AFSC Form 258/258-4 was used for recording all maintenance actions related to the F-111A such as removal and reinstallation of components, fix-in-place repair actions, recording functional checks and troubleshooting actions.

The completion and editing of the Forms 258 was the responsibility of the F-111 JTF maintenance organization. After the forms had been completed they were keypunched, edited, and used to update the maintenance master history file of the SEDS Data Base at regular intervals.

MISSION DEBRIEFING DATA

The AFFTC Form 0-294 (figure 2) was used to record the aircrew's analysis of a mission and to report system malfunctions that occurred during a mission. Information on the form included mission parameters such as aircraft serial number, mission number, date of the mission, duration of the flight, mission effectiveness, and codes which reflected the reliability of the various subsystems which were used during a mission. The following codes were used to record the subsystem reliability:

Code	Meaning
No Entry	Subsystem not used.
1	Subsystem operated satisfactorily.
2	Subsystem had a malfunction, but could be operated in a degraded state.
3	Subsystem was completely inoperative but did not cause a mission abort.
4	Subsystem failed and caused a mission abort.
5	Subsystem was flown with a known discrepancy.

If more than one malfunction was noted on a single subsystem, the reliability code of the most serious deficiency was used. The form was also used to record a brief narrative of the individual discrepancies and sufficient information to correlate the malfunction with the AFSC Forms 258/258-4 which were used to document troubleshooting and repair.

Accurate completion of the form was the responsibility of the aircrew, the JTF reliability engineer, and the JTF maintenance analysts. The forms were reviewed by the JTF reliability engineer and then keypunched into card form to update the master debriefing file of the SEDS Data Base.

SEDS DATA BASE

The SEDS Data Base was structured in the following manner. Each AFSC Form 258 maintenance report constituted a line item record in the maintenance part of the data base. Similarly, each AFFTC Form 0-294 mission debriefing report constituted a line item record in the operational part of the data base.

Even though all maintenance actions were documented on the AFSC Forms 258, this did not mean that all maintenance to repair a particular malfunction was recorded on a single form. Most of the time, more than one form was necessary to document all maintenance actions to clear a malfunction. A maintenance event was defined as all maintenance actions relating to a particular malfunction between discovery of the malfunction and the final fix.

A SEDS computer program tied all related AFSC Forms 258/258-4 into a maintenance event. In addition, this program located the key work unit code of the maintenance event, totaled the maintenance hours, and identified the action taken to fix the malfunction.

During the Category II test of the F-111A there were approximately 30,000 line items recorded in the maintenance data base. The mission debriefing data base contained approximately 1,050 line item records resulting from Category II testing.

To yield an analysis of system maintainability comparable to that of production aircraft, the maintenance data base was taken as the period 1 January 1968 through 31 October 1969 except for maintenance manhour per flying hour total period calculations which were accomplished for the period 1 November 1968 through 31 October 1969. The operational data base, 1 July 1968 through 31 October 1969, was used for reliability analysis.

RELIABILITY ANALYSIS

The data presented here was intended to provide numerical analysis of subsystem reliability. Reliability data was obtained by using failure information from the master debriefing file; therefore, the study was based on aircrew noted malfunctions. As subsystem malfunctions occurred they were classified as degraded operations or failures. A degraded operation existed when the performance of a subsystem was below normal operating specifications, but was still usable. When a subsystem was rendered inoperative or unusable, the malfunction was classified as a subsystem failure. There were two types of subsystem failures, no-abort and abort failures. No-abort failures occurred when the subsystem failed, but was not mission essential and did not cause a mission to be aborted due to the malfunction. When a subsystem was mission essential and had a failure that caused the mission to be terminated before completion, the malfunction was classified as an abort failure.

The probability of mission success as measured during testing at Edwards AFB was 0.83 compared to the specified figure of 0.85. All missions were scored as successes or aborts. A ground abort occurred when the crew had to shut down engines and/or a repair was required to fix a major malfunction with which the pilot would not have taken off. An air abort occurred when a safety of flight malfunction caused termination of the flight or a complete breakoff of the primary mission was caused by a subsystem malfunction. Missions which might have been aborted in an operational environment were considered successes during this program when part of the planned mission test objectives were met. For this reason, the measured probability of mission success (0.83) could be misleading for operational aircraft.

SUBSYSTEM MISSION MALFUNCTION REPORT

The Subsystem Malfunction Report, table II, shows the flight time and number of malfunctions that occurred on the different aircraft subsystems. Also shown is the number of missions on which each subsystem had no malfunctions. The operating time of a subsystem was taken to be the time of each flight on those missions when the subsystem was used.

During the period of July 1968 through October 1969, the F-111A flew 512 missions, including ground aborts, for a total of 950 hours. Examination of table II shows that the subsystems having the malfunctions were propulsion, attack radar, flight control, inertial navigation, and instruments, in that order.

SUBSYSTEM MISSION RELIABILITY REPORT

The Subsystem Mission Reliability Report, table III shows calculated values of the mean times between malfunctions according to type and the probabilities of not having a malfunction of each type. The following statistics were calculated for each subsystem and are shown in table IV:

1. Mean time between discrepancies (MTBD)
2. Mean time between failures (MTBF)
3. Mean time between aborts (MTBA)

These values were computed as follows:

$$MTBD = \frac{T}{N_d + N_f + N_a}$$

$$MTBF = \frac{T}{N_f + N_a}$$

$$MTBA = \frac{T}{N_a}$$

Where:

T = Total system operating time

N_d = Number of degraded operations recorded on the subsystem

N_f = Number of no-abort failures recorded against the subsystem

N_a = Number of abort failures recorded against the subsystem

In addition, the statistically derived 90-percent lower confidence limits for the means were calculated. A 90-percent lower confidence limit (for a given parameter) was that value which the true value would equal or exceed for a given sample size with 90 percent probability. As such, the proximity of the 90-percent lower confidence limit to the measured mean gives an indication of the certainty that should be attached to the measured mean. In other words the closer the measured value is to the 90-percent lower confidence limit, the more certaintly of the measured value being the true value.

The method used to determine the lower confidence limit employs the chi-square (χ^2) distribution using fixed truncation time for the tests:

$$\text{Lower Limit} = \frac{2\,T}{\chi^2\ (\alpha,\ 2R + 2)}$$

Where:

T = Total test time

R = Number of failures accumulated

α = Acceptable risk of error (10 percent) or

$1-\alpha$ = Confidence level (90 percent)

χ^2 = The critical value for the chi-square distribution with risk, α, and the degree of freedom, $2R + 2$.

Table III also contains the following statistics computed to show the probability that a subsystem will be usable on any mission regardless of duration:

1. Probability of no discrepancies (P_{nd})
2. Probability of no failures (P_{nf})
3. Probability of no aborts (P_{na})

These probabilities were calculated as follows:

$$P_{nd} = \frac{N_s}{N_s + N_d + N_f + N_a}$$

$$P_{nf} = \frac{N_s + N_d}{N_s + N_d + N_f + N_a}$$

$$P_{na} = \frac{N_s + N_d + N_f}{N_s + N_d + N_f + N_a}$$

Where:

N_s = Number of successful missions flown on a subsystem.

The 90-percent lower confidence limits associated with the probabilities are also included in table III. The following binomial distribution equation was used to solve for the lower confidence limits:

$$\sum_{i=N_s}^{N} \binom{N}{i} (p)^{i} (1-p)^{N-i} = \alpha$$

Where:

N = sample size

N_S = number of successful missions

p = lower confidence limit probability (90 percent)

α = acceptable risk level (10 percent)

An iterative method was used to solve the equation for lower confidence limit. The large difference between some of the measured mean times and probabilities and the associated lower confidence limits results from the low utilization rates of some subsystems.

Table IV shows a comparison between the measured MTBF's and the contract end item (CEI) specified or allotted MTBF's for aircraft subsystems. There is a difference in the method of calculation of these two MTBF's. The specified MTBF is in terms of total operating time, while the measured value is in flying hours. Time that is not included in the measured MTBF is system runup, alinement, and checkout. Regardless of this difference, there is a substantial difference between the specified and measured values except for the LCOS and UHF communications. The RHAWS and CMRS had insufficient testing to determine a mean time between failures.

MAINTAINABILITY ANALYSIS

All maintenance data collected in the 258 Data System from January 1968 through October 1969 was the basis of the F-111A maintainability analysis. An analysis of maintenance man-hours per flying hour (MMH/FH), the probability distributions of maintenance events, and the time to turn around the aircraft are presented.

Work unit codes (WUC's) were used in maintenance data recording to identify the specific hardware item that was being worked on or to identify a type of maintenance. These are five-digit alpha/numeric codes specified in the Work Unit Code Manual Technical Order 1F-111A-06 (reference 2). The first two digits of a work unit code designate an aircraft system. For example 23 identifies the propulsion system and 73 identifies the bombing navigation system. The third digit identifies subsystems within the system. The fourth and fifth digits designate assemblies and components. As an example, work unit Code 73, bombing navigation, consists of the inertial navigation, attack radar, terrain following radar, and the radar altimeter subsystems. Maintenance accomplished and documented against aircraft systems is termed non-support general and is accomplished on the line or in the shop.

Work unit codes 01 through 09 designate support general maintenance actions such as servicing, phase inspections, and aircraft cleaning.

The maintainability analysis was reported for the two-digit aircraft systems with the exception of avionics which was reported at the three-digit subsystem level.

MAINTENANCE MAN-HOURS PER FLYING HOUR

The MMH/FH of each aircraft system was calculated by retrieving maintenance data from the F-111A master history file by the two-digit work unit code and dividing the sum of maintenance man-hours for each WUC by the total flying time for that period.

The MMH/FH was separated into line and shop actions. Further distinction was made between support and non-support general maintenance events. Support general maintenance was denoted by WUC 01-09. Non-support general maintenance was unscheduled maintenance, such as repair of malfunctions discovered during a mission, and was designated by WUC's 11-97.

The total MMH/FH and the percent of total was presented for each aircraft system. In addition, subtotals for support and non-support MMH/FH and system total MMH/FH are shown.

Table V contains the MMH/FH figures for October 1969. Six-month average MMH/FH's for May 1969 through October 1969 are presented in table VI. The average values were calculated for the period from November 1968 through October 1969 and are presented in table VII. The final average values were taken for the period November 1968 through October 1969. By using only the most recent 12 months' data, a set of figures including the effects of aircraft modifications and newest maintenance techniques were available.

MMH/FH bar graphs for each work unit code are presented in figures 3 through 8. These were the 6-month moving averages of the MMH/FH. Figure 9 is the same type presentation for all support general and non-support general subtotals. The total aircraft MMH/FH moving averages are shown in figure 10.

Figure 11 was included to give a comparison between the MMH/FH expended on the different aircraft subsystems and support general WUC's and the contractors predicted values for these subsystems and WUC's.

Table VIII contrasts the contractor's predicted MMH/FH and the measured MMH/FH for the Category II testing (reference 3). Also tabulated are the differences between the MMH/FH's and comments on the difference.

Thirteen subsystems met the contractor's predicted values. However, the overall MMH/FH for the F-111A in Category II testing was 82.3 MMH/FH as compared with 32.7 MMH/FH predicted by the contractor and 35.0 MMH/FH specified in the contract. For a breakout of the difference, the contractor predicted value for support general maintenance was 8.9 MMH/FH with a measured value of 38.8. This difference of almost 30 MMH/FH is further explained in table VIII. In summary, most of the difference was because the contractor did not include shop support general in his prediction and because of the large number of man-hours used at Edwards in the testing environment for ground handling and look phase inspections.

The contractor predicted 23.8 MMH/FH for non-support general maintenance. The measured value was 43.5. This difference was caused mainly by the low reliability demonstrated by the propulsion and avionics subsystems. Although the mean man-hours to repair these subsystems were relatively high, the low mean time between discrepancies was the major factor.

DISTRIBUTION OF MAINTENANCE EVENTS

A maintenance event consisted of all maintenance actions, both line and shop, required to repair a particular malfunction. Associated with each event are the active hours and the man-hours required to repair the malfunction. For each maintenance event the following parameters were reported on here:

1. Line active hours
2. Line man-hours
3. Shop active hours
4. Shop man-hours
5. Total active hours
6. Total man-hours

For each of the above the mean, standard deviation, median (the time when 50-percent of all maintenance events will be completed) and M_{max} (the time when 90-percent of all maintenance events will be completed) are presented in tables IX through XIV. These statistics were calculated so as not to depend on any particular probability distribution, so they are termed non-parametric statistics.

In addition to non-parametric statistics, it is useful to fit the times to repair to a probability distribution so that one can obtain the probability that the aircraft system will be repaired within a specified time interval. To this end, tests were made for the maintenance events of each system to determine which of the three following probability distributions fit best:

1. Log-Normal Distribution - where t is the active hours or man-hours to repair and μ and σ^2 are the distribution parameters,

$$f\,(t|\mu,\,\sigma) = \frac{1}{t\;\sigma\sqrt{2\pi}}\;\exp\left[-\frac{1}{2}\left(\frac{\log_e t-\mu}{\sigma}\right)^2\right]$$

2. Exponential Distribution - with the parameter θ,

$$f\,(t|\theta) = \frac{1}{\theta}\exp\left(-\frac{t}{\theta}\right)$$

3. Weibull Distribution - with parameters θ_1 and θ_2,

$$f(t|\theta_1,\theta_2) = \theta_1\theta_2 t^{(\theta_2-1)}\;\exp\,(-\theta_2 t^{\theta_2})$$

The Kalmogorov-Smirnov goodness of fit test was used to determine which distribution best fit the data. Tables IX through XIV list the parameter values for each best fit distribution.

Figures 12 through 18 are plots of the actual data, fitted distribution, and 95-percent confidence bounds for the following subsystems:

1. Autopilot
2. Air Data System
3. Inertial Bomb Navigations
4. Attack Radar
5. Radar Altimeter
6. Terrain Following Radar (TFR)
7. Lead Computing Optical Sight (LCOS)

The two curves representing the upper and lower 95-percent confidence bounds are interpreted to mean that we know with 95-percent confidence that the true distribution of the maintenance events lies between these two curves. The non-parametric statistics shown are calculated from available data and as such are limited in the information provided by a given sample. The best fit distribution is a model which portrays and predicts the complete maintenance behavior of the particular subsystem more completely than just the mean. The probability of completing a repair action within a certain length of time can be determined by finding the time in hours (or man-hours) on the abscissa going up to the distribution curve and reading ac s to the ordinate.

For some subsystems ed in tables IX through XIV, it was not possible to fit a parametric distribution to the different categories of time expenditure. In some cases, such as the airframe or landing gear subsystems, the subsystem is too large and may require too varied a collection of maintenance tasks to fit any distribution. Other subsystems such as flight controls have electrical and mechanical components and therefore, the resulting maintenance requirements are too diverse to fit any standard distributions. Small sample size also caused some subsystems not to fit, and combinations of the three problems listed caused still other misfits.

TIME TO TURN AROUND

A time to turn around was calculated by considering support general maintenance work necessary to service the aircraft after one flight to prepare for the next flight. A list of work unit codes considered as part of turn around maintenance is shown in table XV. Two categories of maintenance time were considered in determining time to turn around; active time, and man-hours. The mean, median, standard deviation, and M_{max} for these two categories are summarized in table XVI.

CONCLUSIONS

RELIABILITY

The mean time between failures obtained for the various avionic subsystems during Category II testing were much lower than the CEI specified MTBF's. These findings should not be discounted "out of hand" just because the test aircraft were pre-production models. A comparison of the particular subsystem of interest in both pre-production and production aircraft must be performed before a valid conclusion can be made.

The probability of mission success as measured at Edwards AFB was 0.83 while the specified figure was 0.85. Missions which might have been aborted in an operational environment were considered successes at Edwards when part of the planned mission test objectives were met. For this reason, the measured probability of mission success (0.83) could be misleading for operational aircraft.

MAINTAINABILITY

Aircraft design has made component accessibility easy. Being able to reach test points, operate built-in test functions, and remove components at ground level has reduced preparation time for many maintenance tasks.

The maintainability of the aircraft was generally good, but the low reliability of some of the avionics subsystems and the propulsion subsystem caused a high maintenance man-hour per flying hour figure.

The specified MMH/FH was 35.0. The value measured at Edwards during the last year of Category II testing was 82.3. For support general tasks, the difference of 30 MMH/FH between contractor predicted and measured occurred because the contractor did not include shop support general (wheel and tie buildup, engine buildup and teardown) in his predictions and because of the large number of man-hours used at Edwards in the testing environment for ground handling and look phase inspections.

Maintenance man-hours per flying hour is as much a measure of reliability as maintainability because a high man-hour expenditure can be caused by high failure rates. As shown in table III many of the subsystems had low values for mean time between in-flight writeups. For nonsupport general tasks (unscheduled corrective maintenance), the contractor predicted 23.8 MMH/FH and 43.5 was measured. This was caused mainly by the low reliability demonstrated on the propulsion and avionics subsystems.

APPENDIX I - TEST DATA

Six-month Moving Average

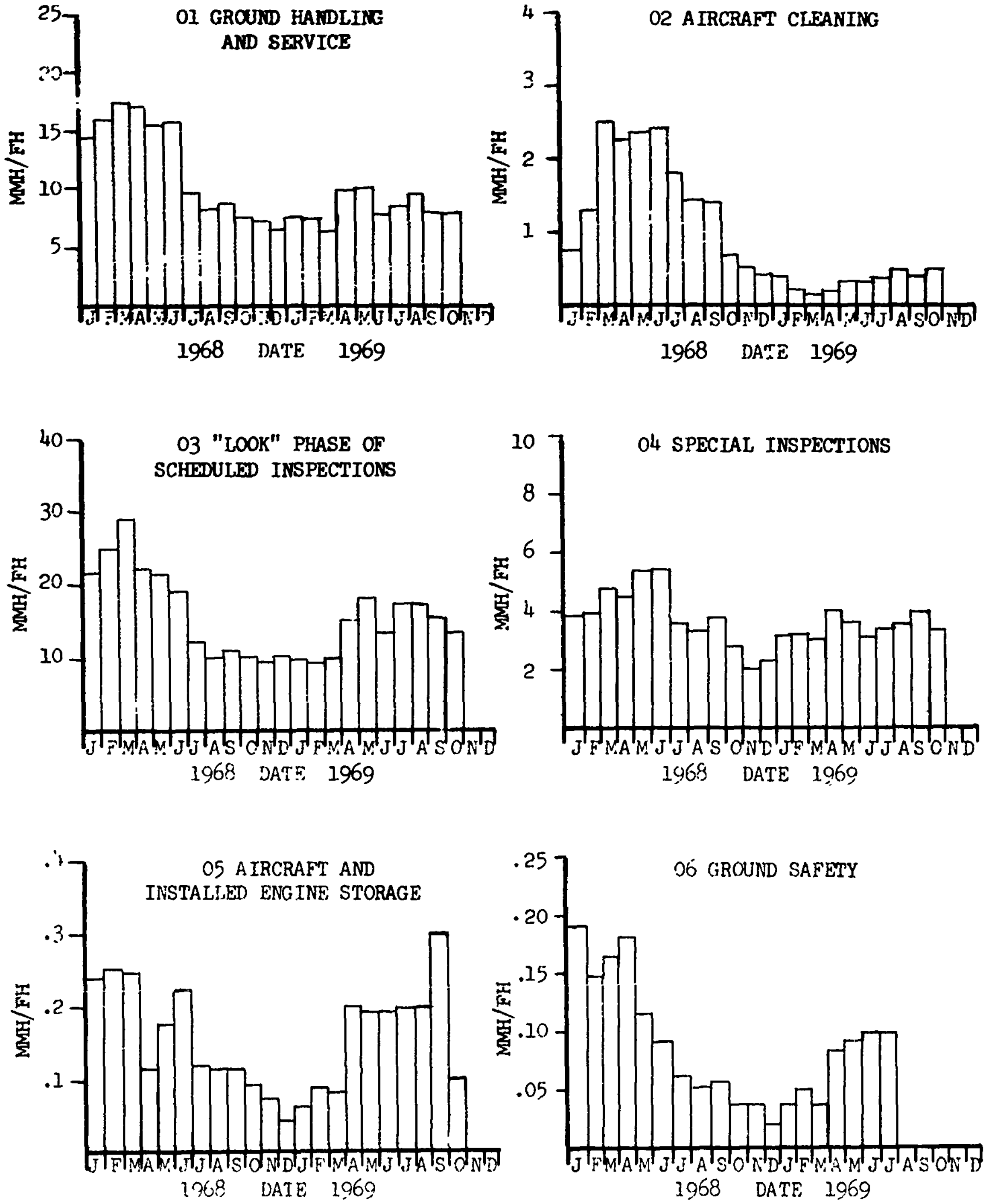


Figure 3 MAINTENANCE MAN-HOURS PER FLYING HOUR BY AIRCRAFT WORK UNIT CODE

Six-month Moving Average

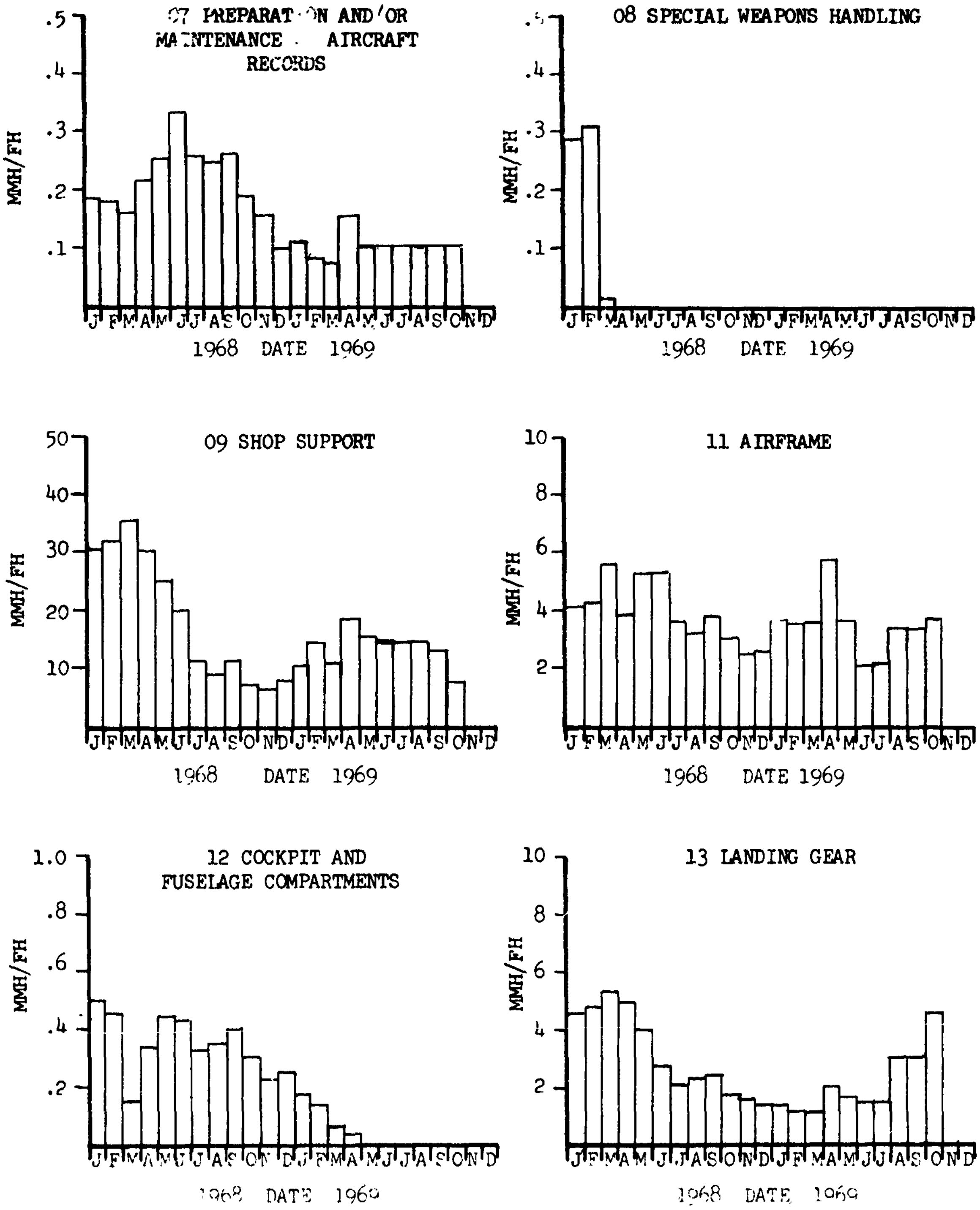


Figure 4 MAINTENANCE MAN-HOURS PER FLYING HOUR BY AIRCRAFT WORK UNIT CODE

Six-month Moving Average

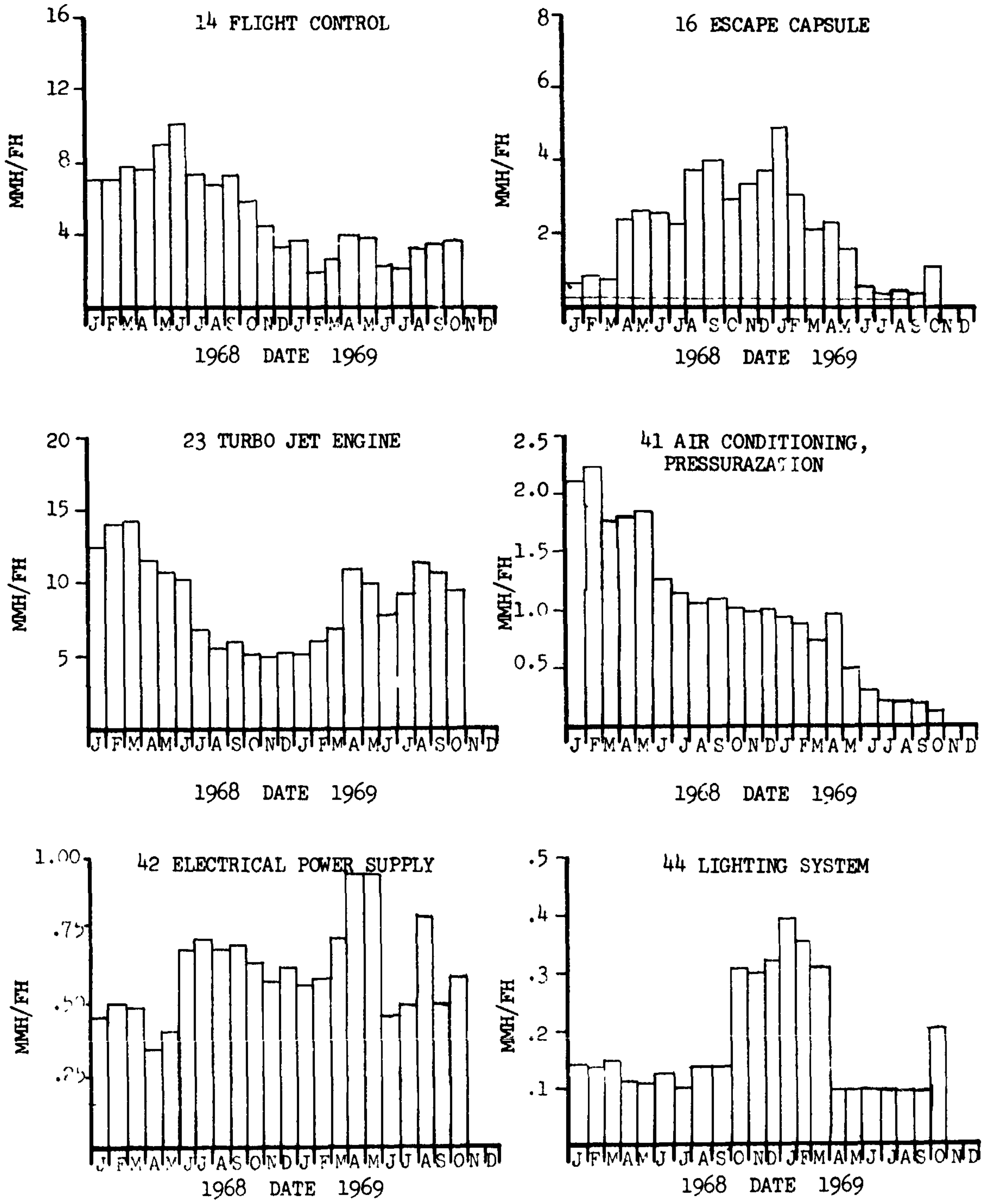


Figure 5 MAINTENANCE MAN-HOURS PER FLYING HOUR BY AIRCRAFT WORK UNIT CODE

Six-month Moving Average

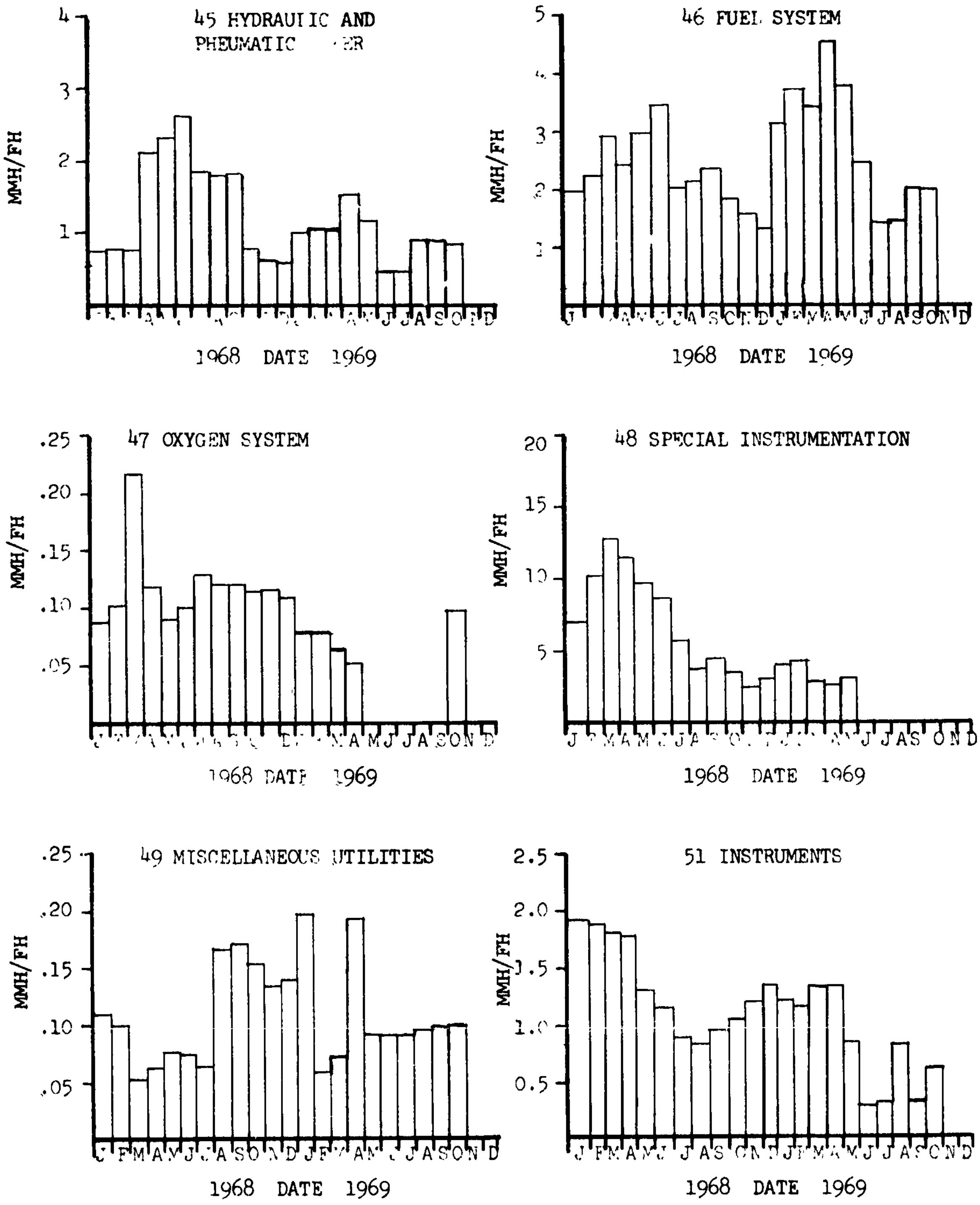


Figure 6 MAINTENANCE MAN-HOURS PER FLYING HOUR BY AIRCRAFT WORK UNIT CODE

Six-month Moving Average

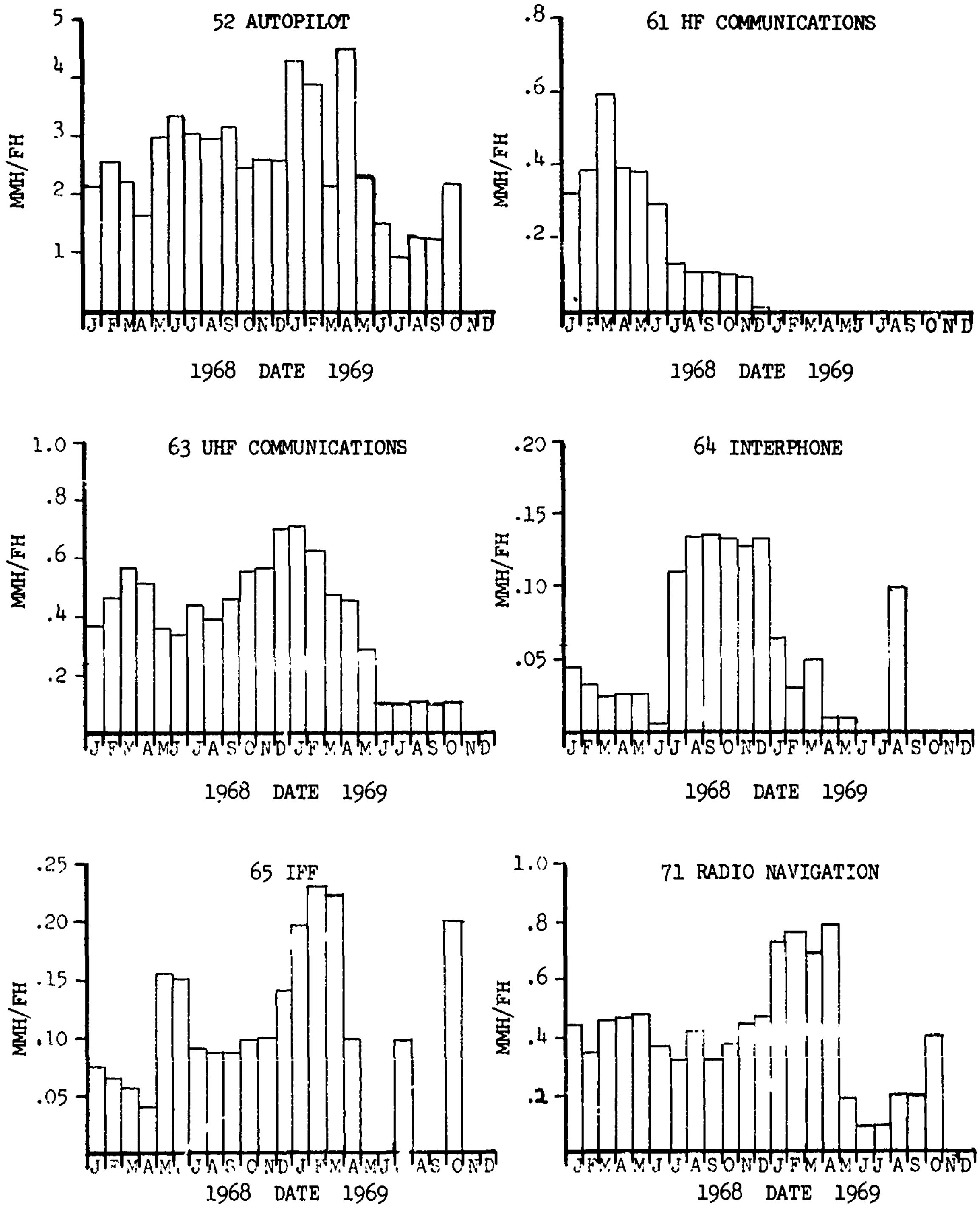


Figure 7 MAINTENANCE MAN-HOURS PER FLYING HOUR BY AIRCRAFT WORK UNIT CODE

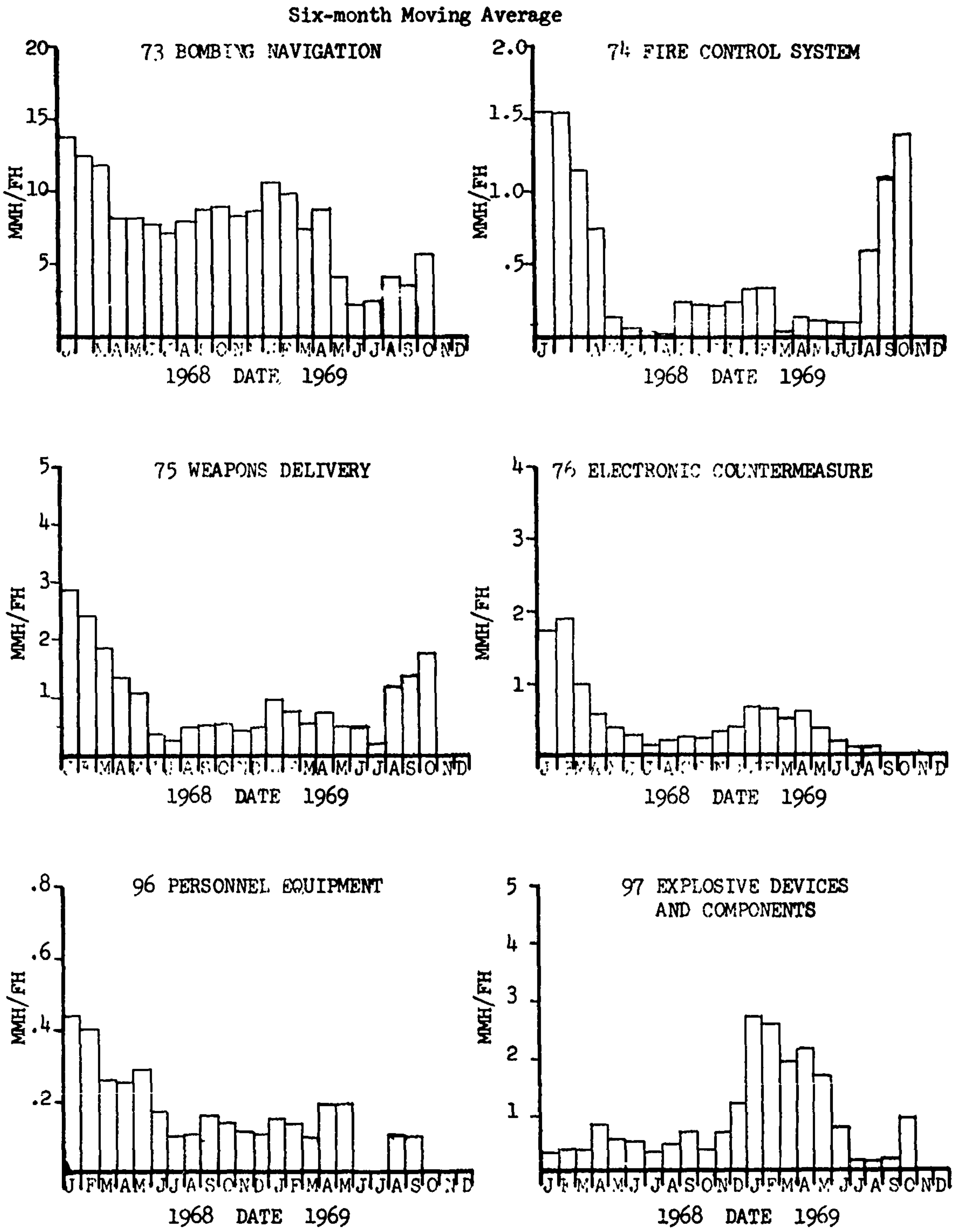


Figure 8 MAINTENANCE MAN-HOURS PER FLYING HOUR BY AIRCRAFT WORK UNIT CODE

Six-month Moving Average

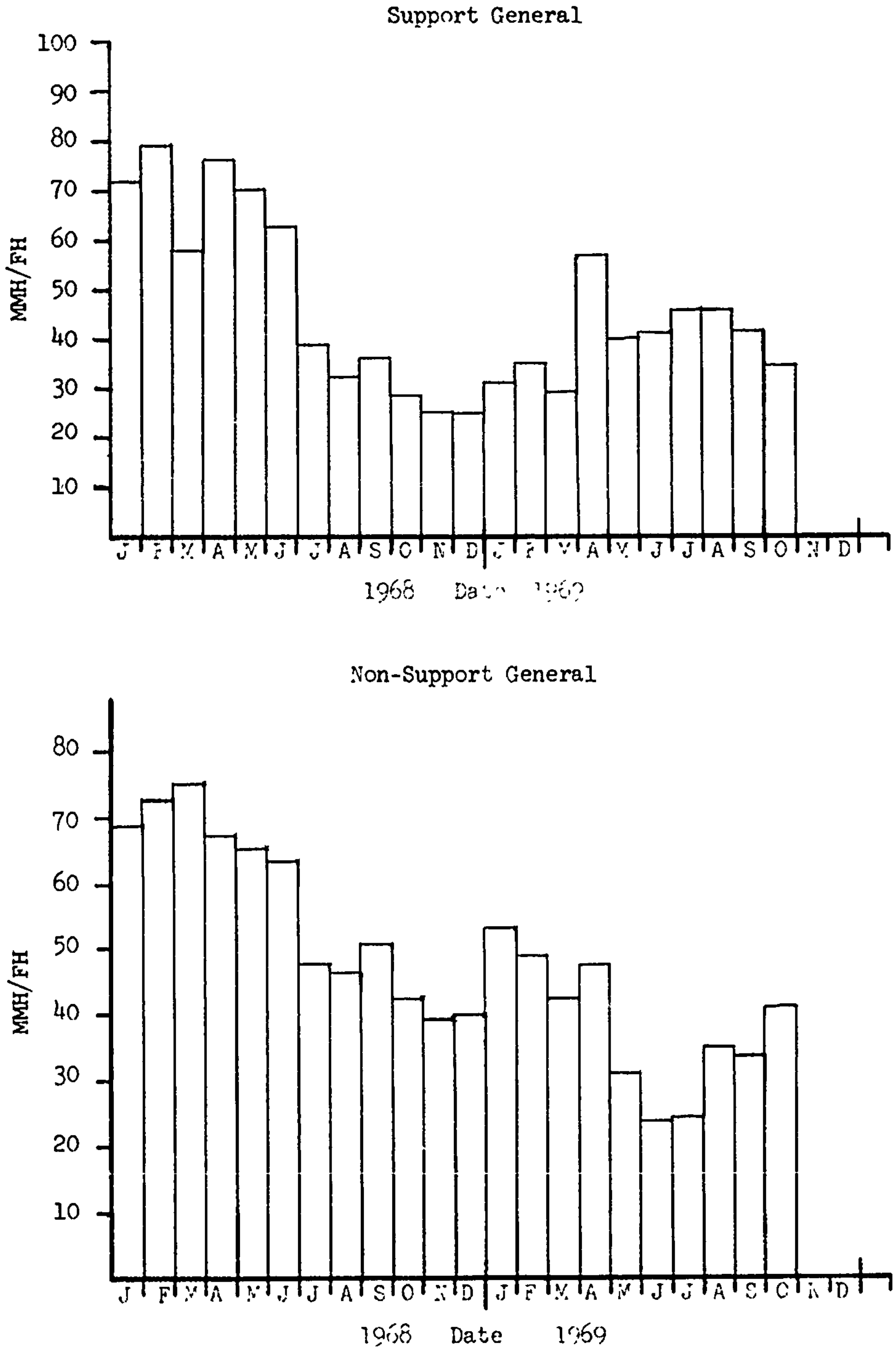


Figure 9 MAINTENANCE MAN-HOUR PER FLYING HOUR, SUPPORT GENERAL AND NON-SUPPORT GENERAL

Six-month Moving Average

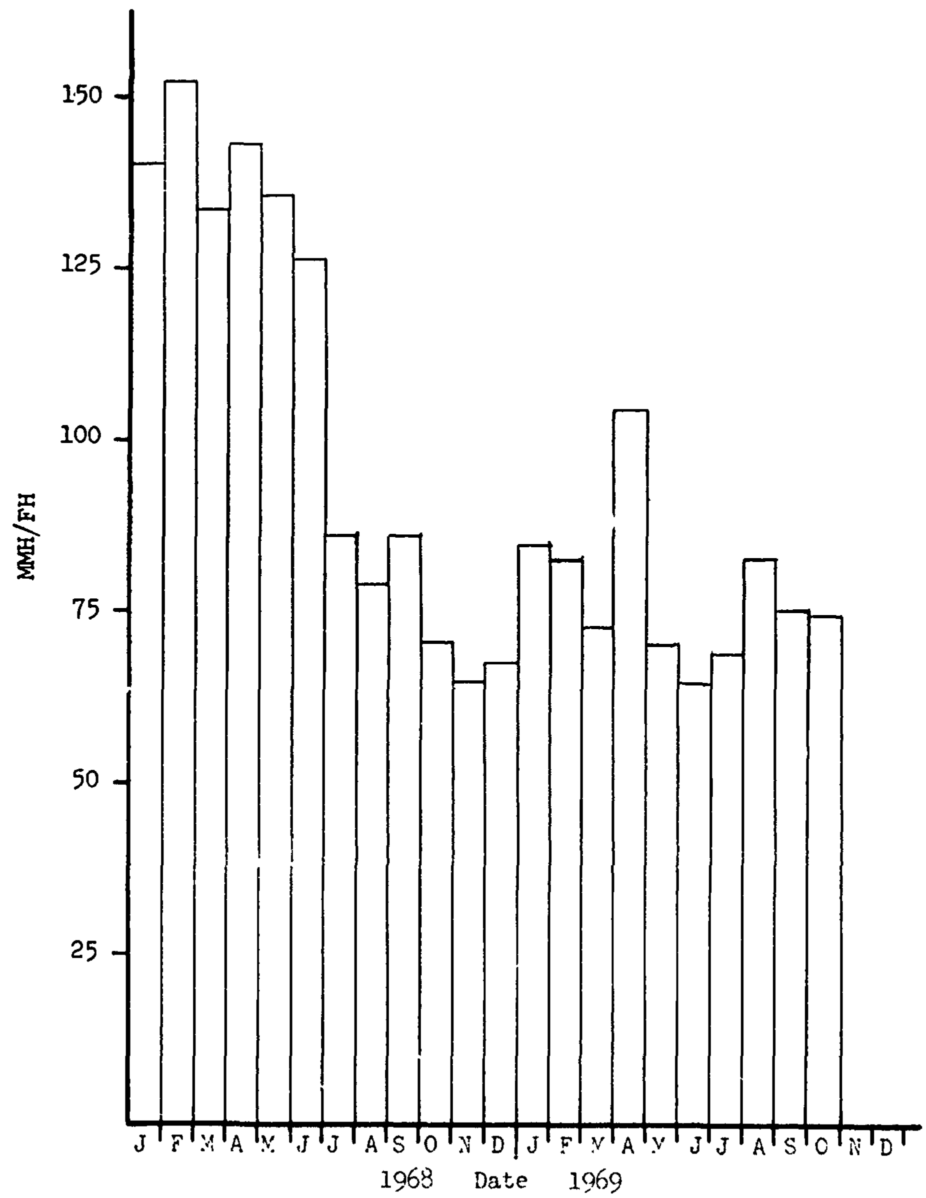


Figure 10 TOTAL SYSTEM MAINTENANCE MAN-HOUR PER FLYING HOUR

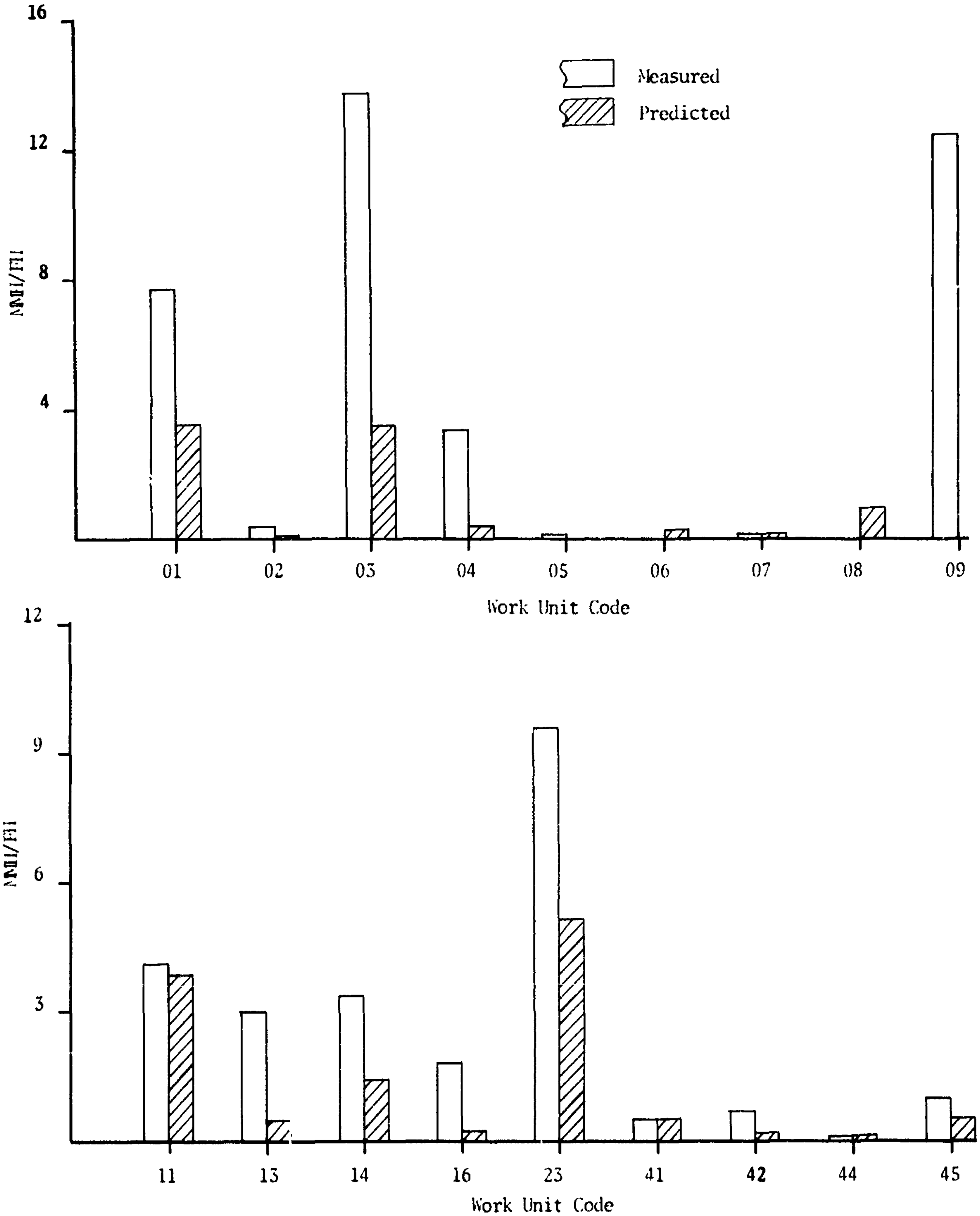
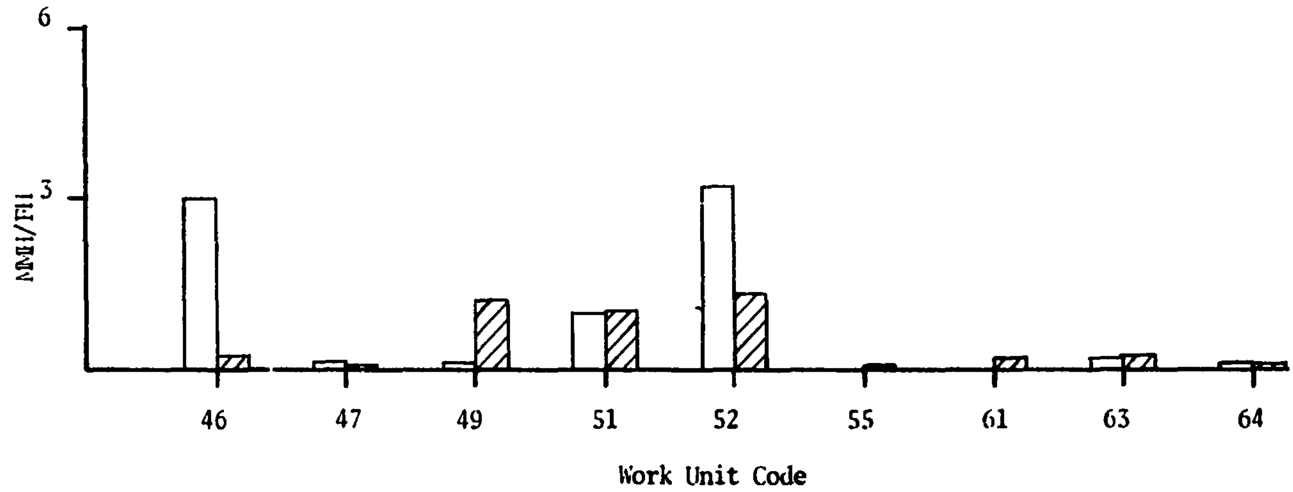


Figure 11 MEASURED AND CONTRACTOR PREDICTED MMH/FH COMPARISON



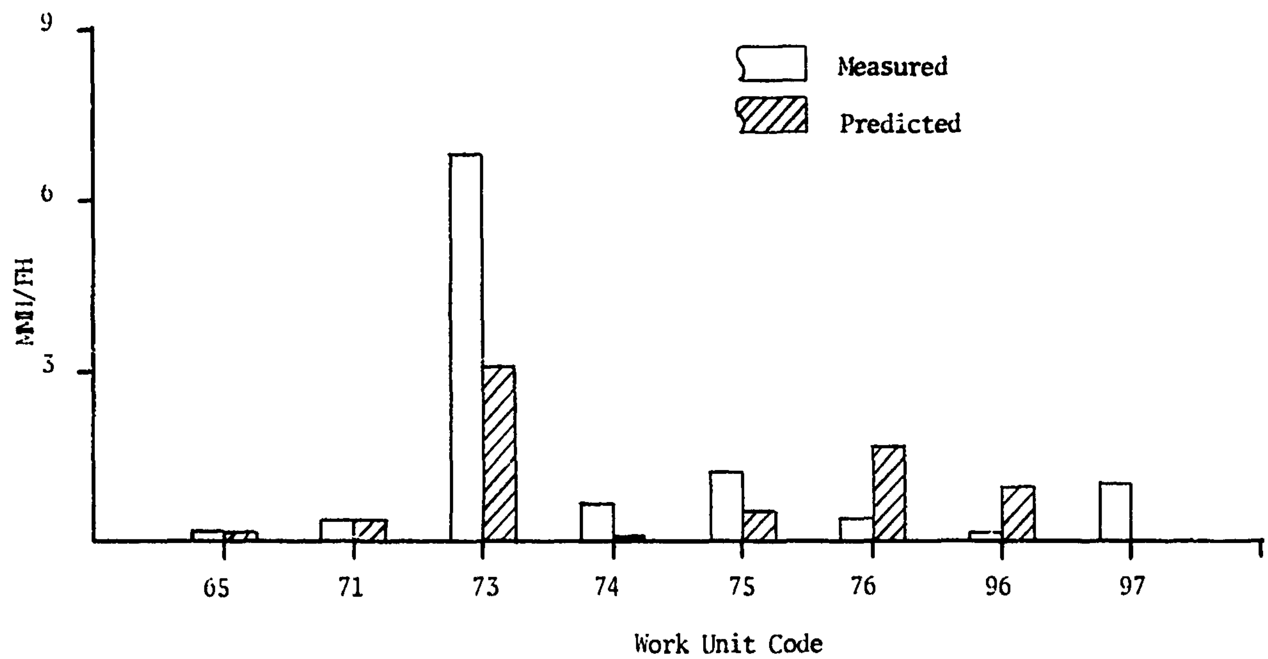


Figure 11 MEASURED AND CONTRACTOR PREDICTED MMH/FH COMPARISON (Concluded)

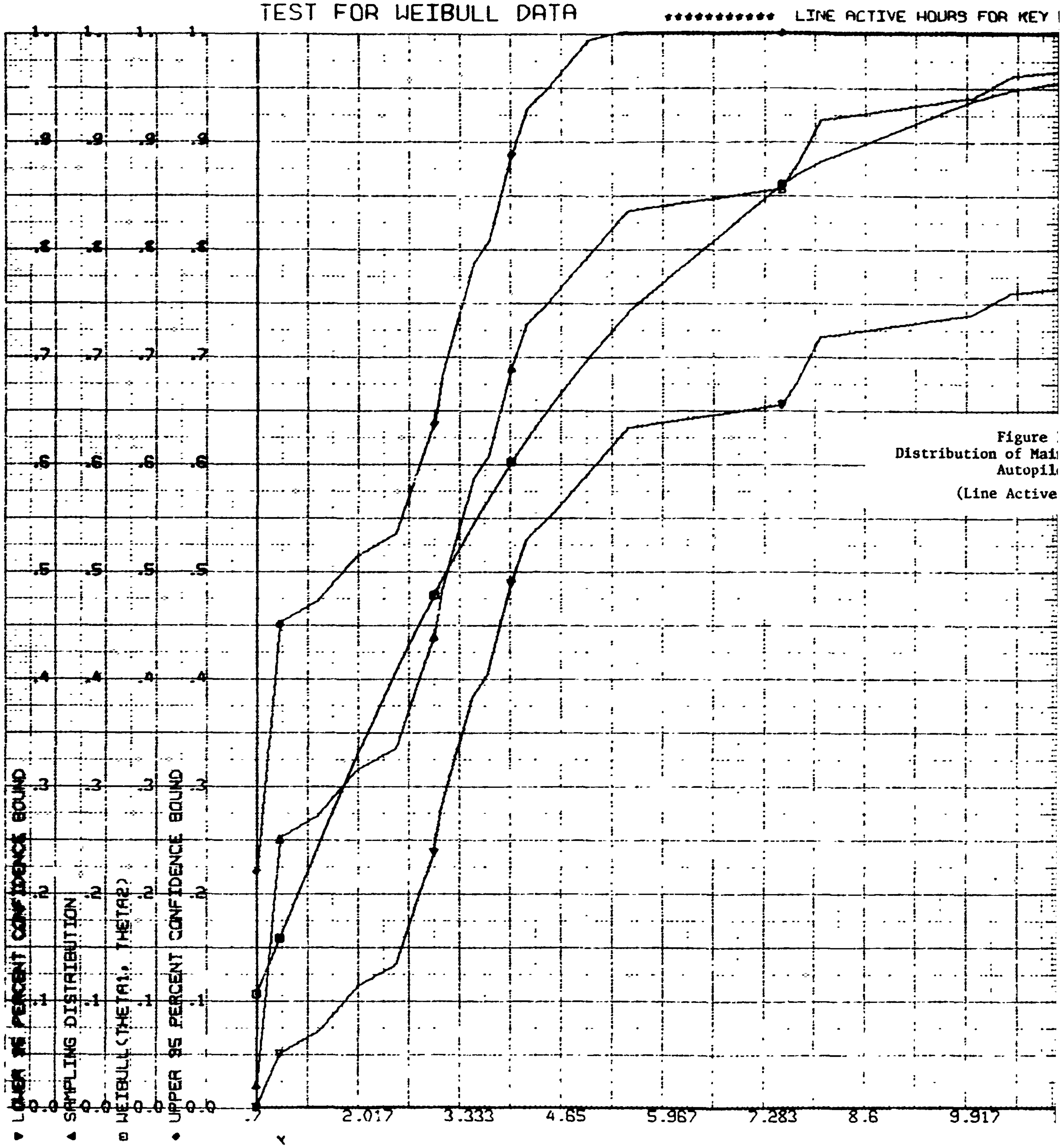


Figure
Distribution of Mai
Autopil
(Line Active

1

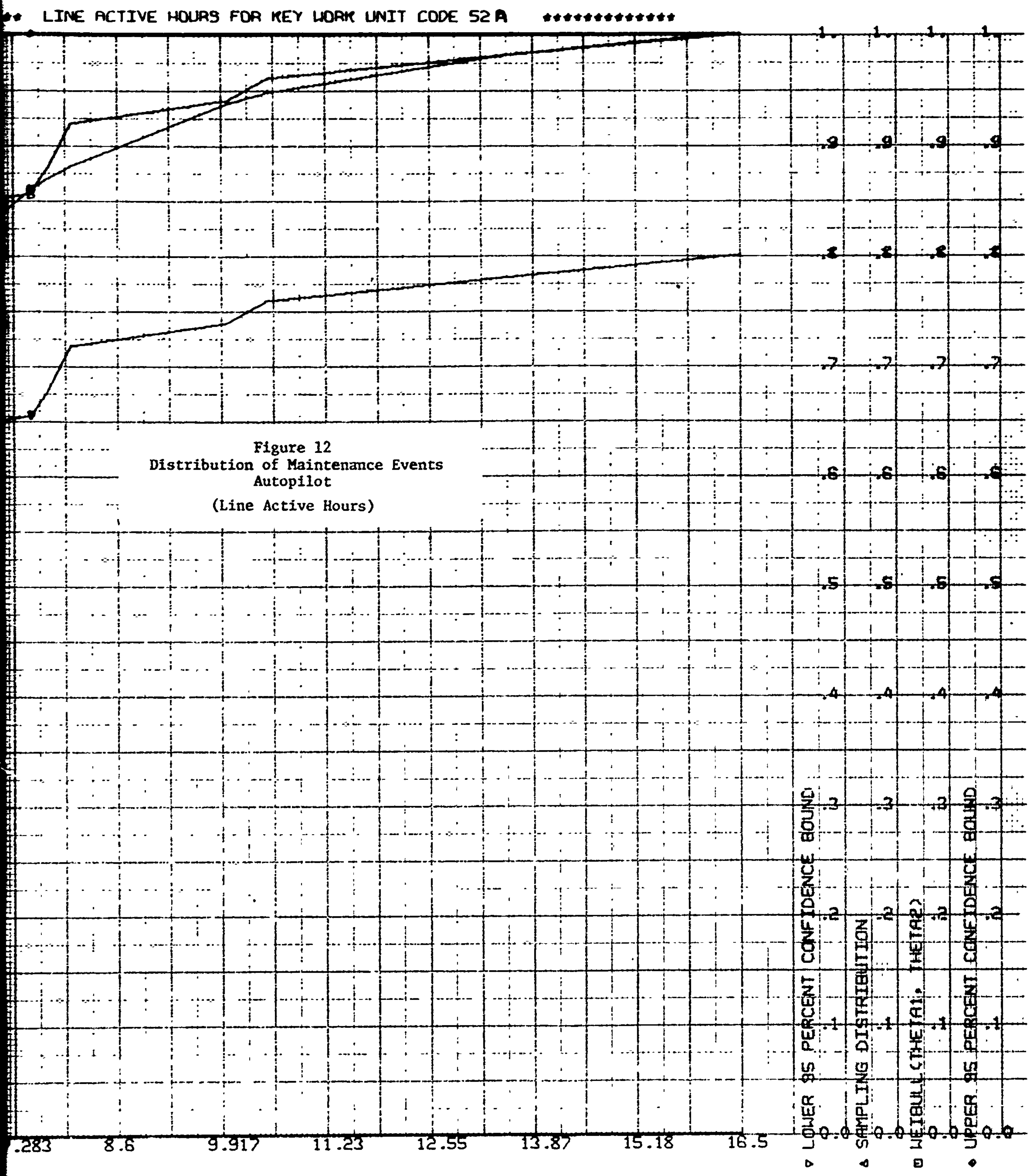


Figure 12
Distribution of Maintenance Events
Autopilot
(Line Active Hours)

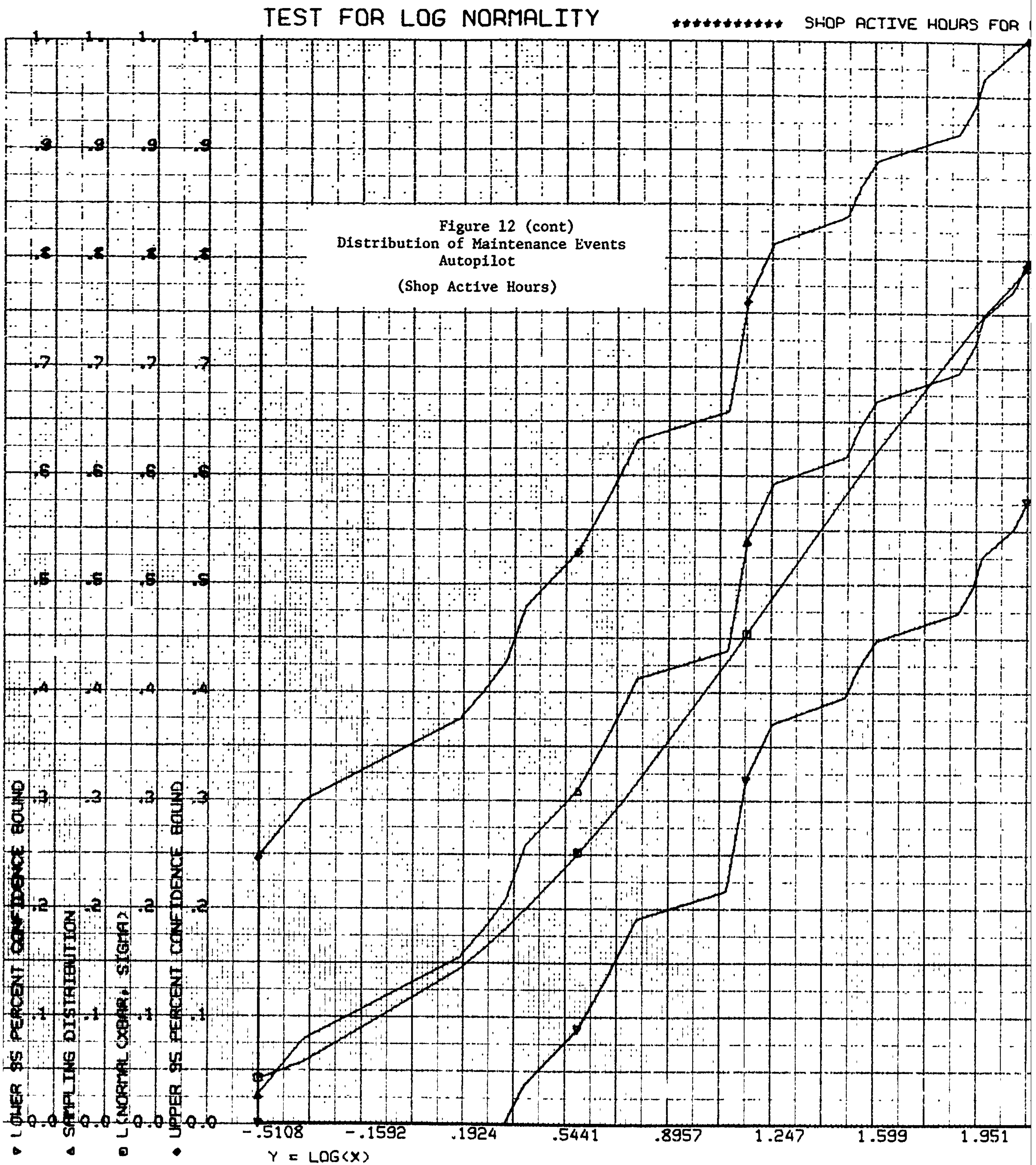
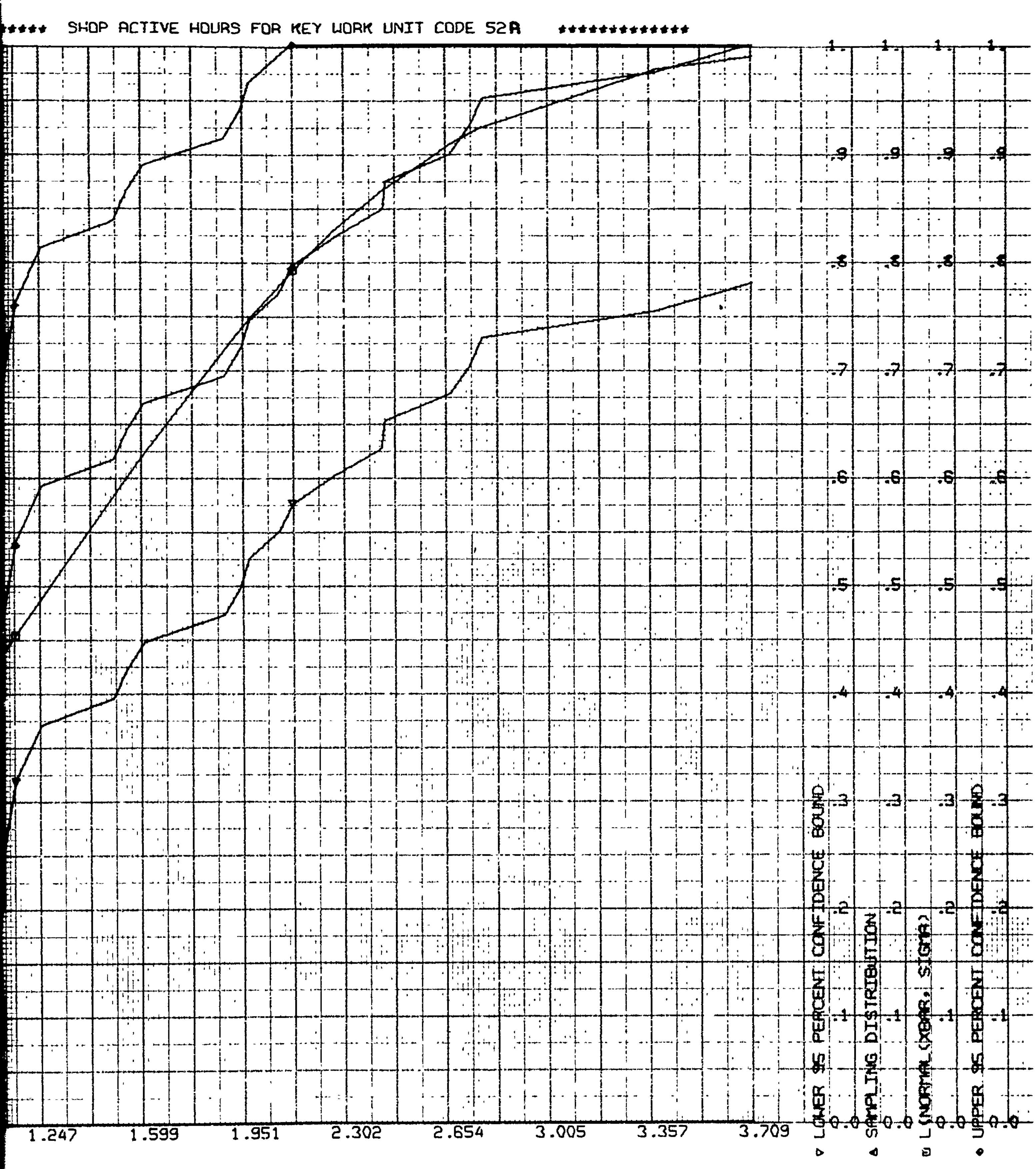


Figure 12 (cont)
Distribution of Maintenance Events
Autopilot

(Shop Active Hours)


***** SHOP ACTIVE HOURS FOR KEY WORK UNIT CODE 52A **************
1.247
1.599
1.951
2.302
2.654
3.005
3.357
3.709
LOWER 95 PERCENT CONFIDENCE BOUND
SAMPLING DISTRIBUTION
L(NORMAL(XBAR, SIGMA)
UPPER 95 PERCENT CONFIDENCE BOUND

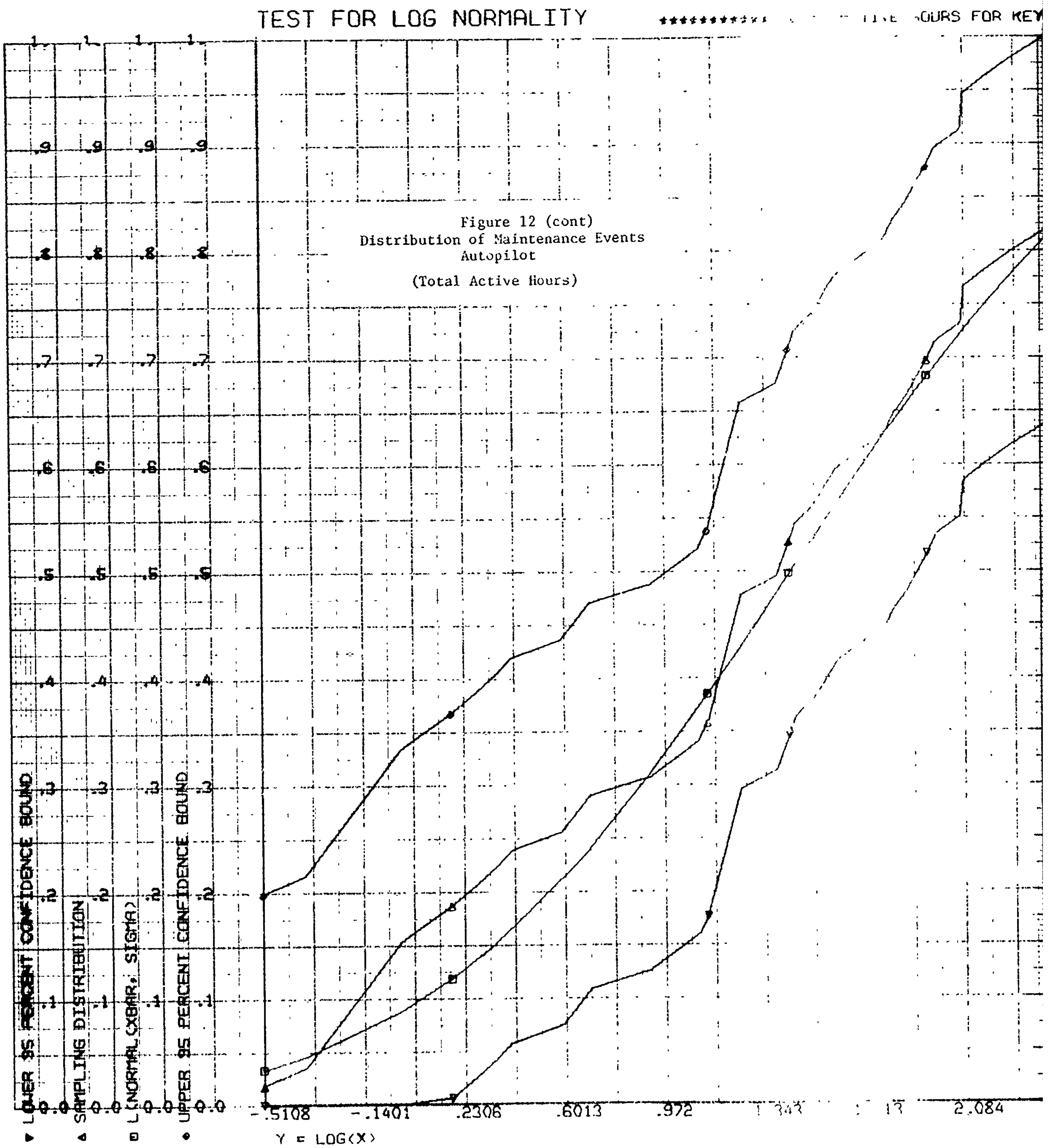
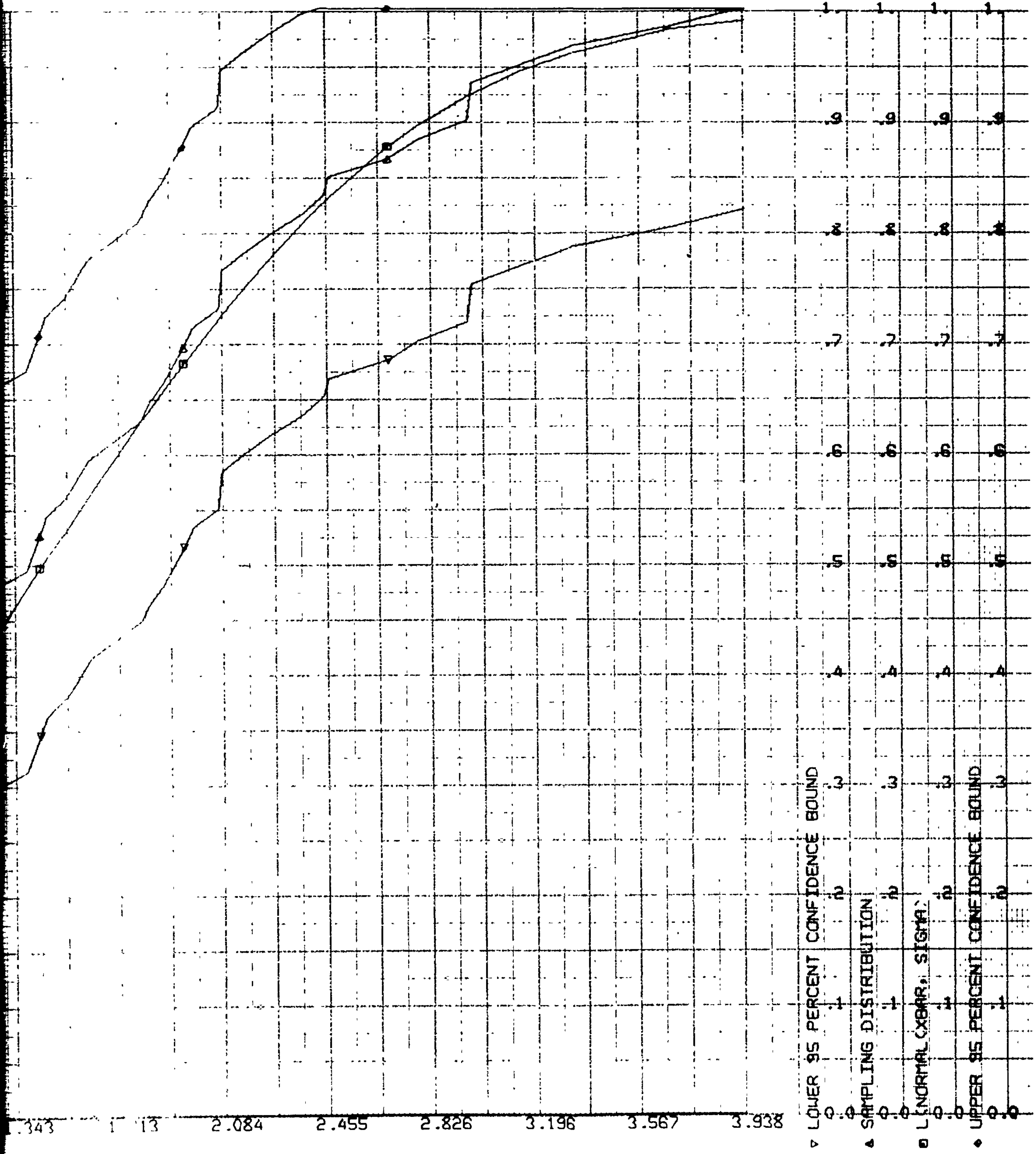


Figure 12 (cont)
Distribution of Maintenance Events
Autopilot
(Total Active Hours)

** TOTAL ACTIVE HOURS FOR KEY WORK UNIT CODE 52A **************



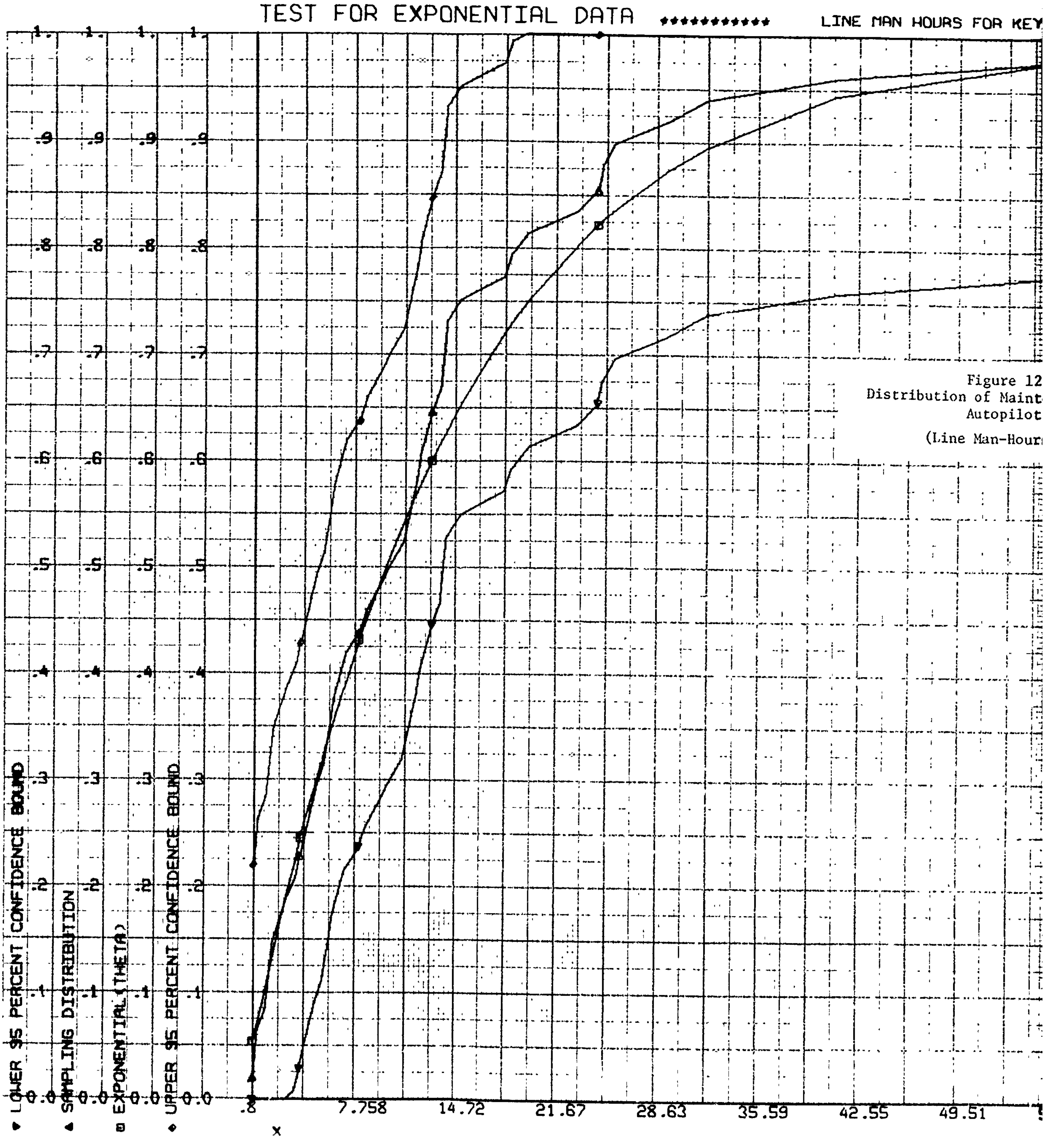


Figure 12
Distribution of Maint
Autopilot
(Line Man-Hour

**** LINE MAN HOURS FOR KEY WORK UNIT CODE 52A **************

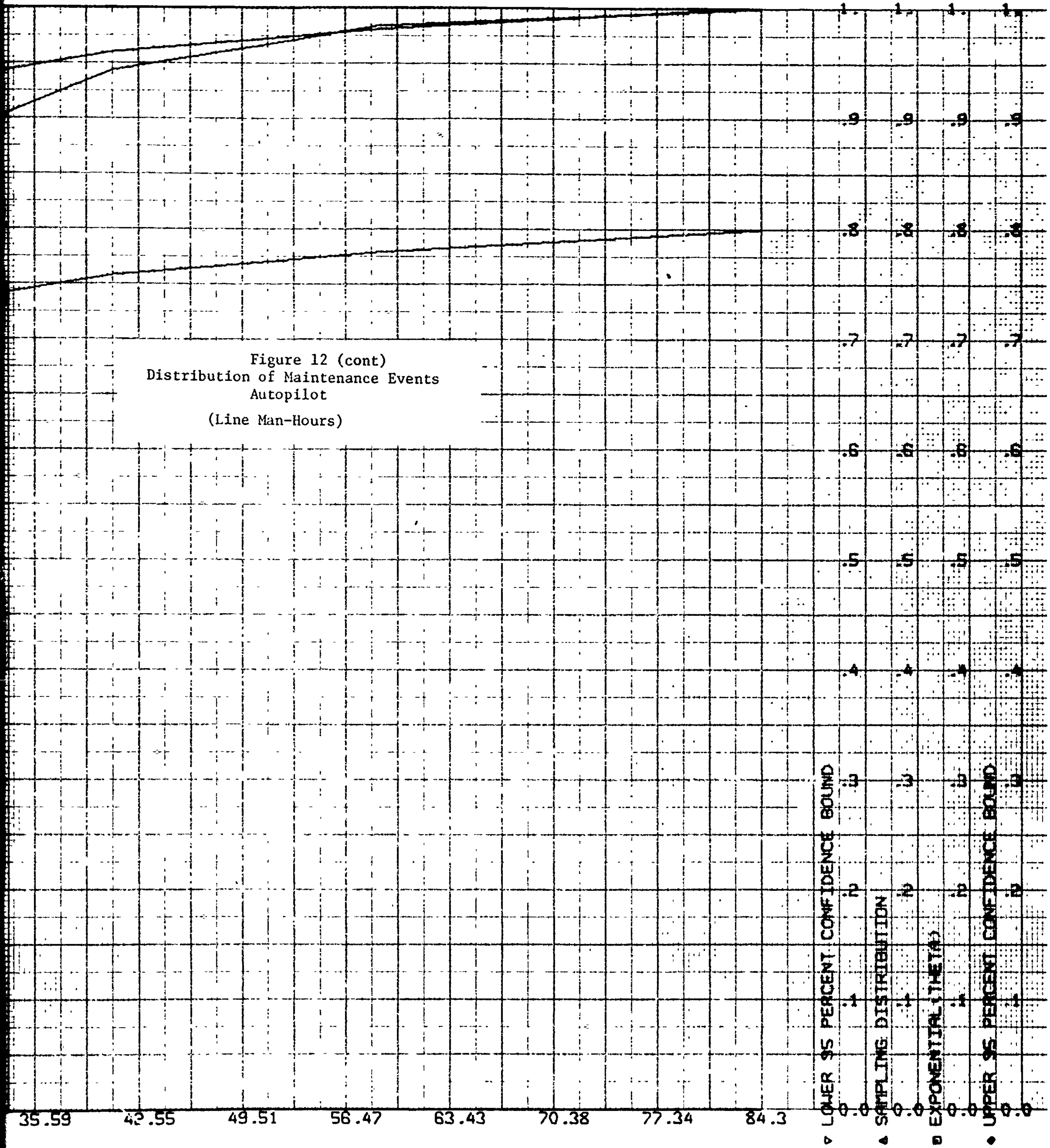


Figure 12 (cont)
Distribution of Maintenance Events
Autopilot

(Line Man-Hours)

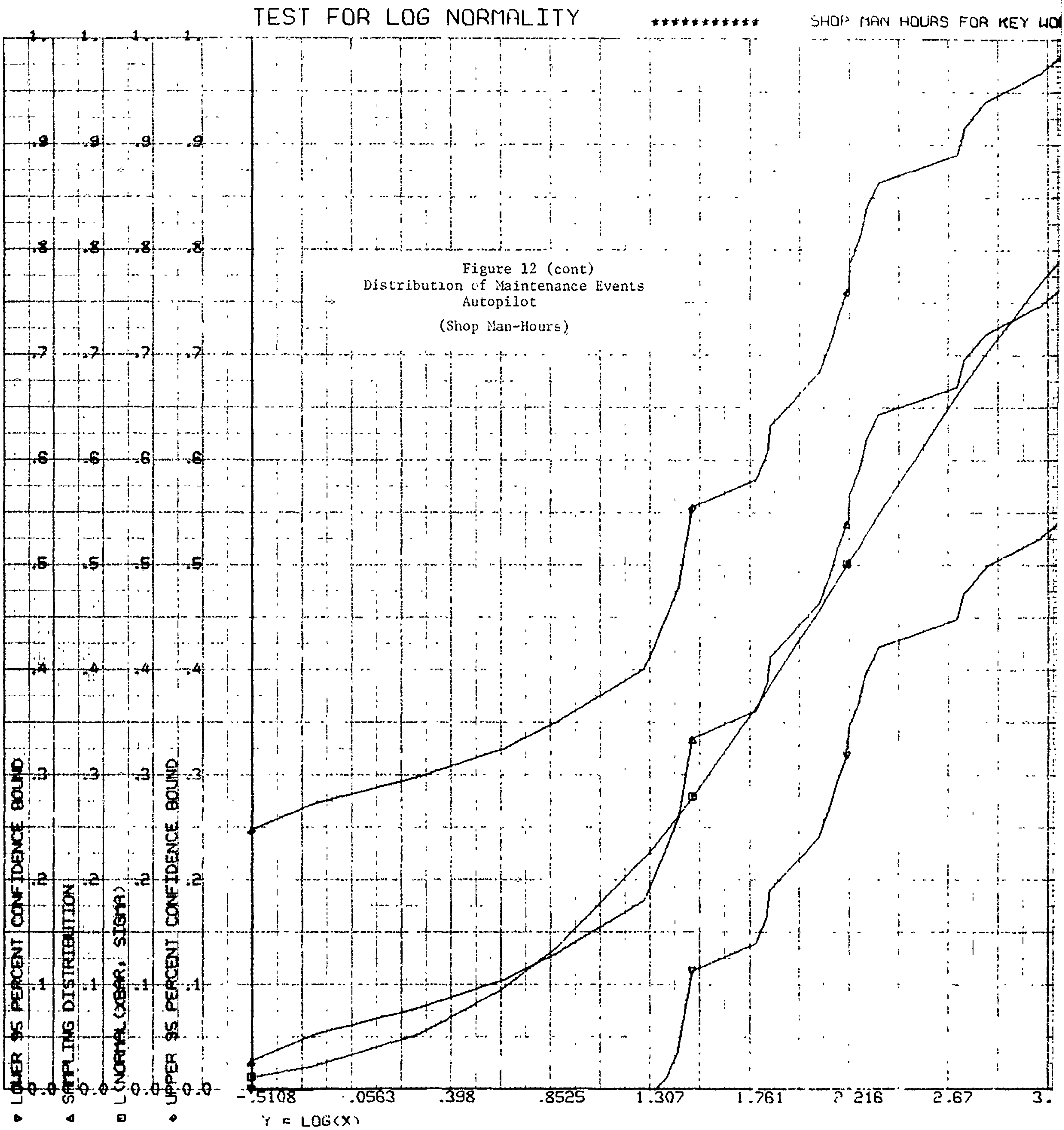
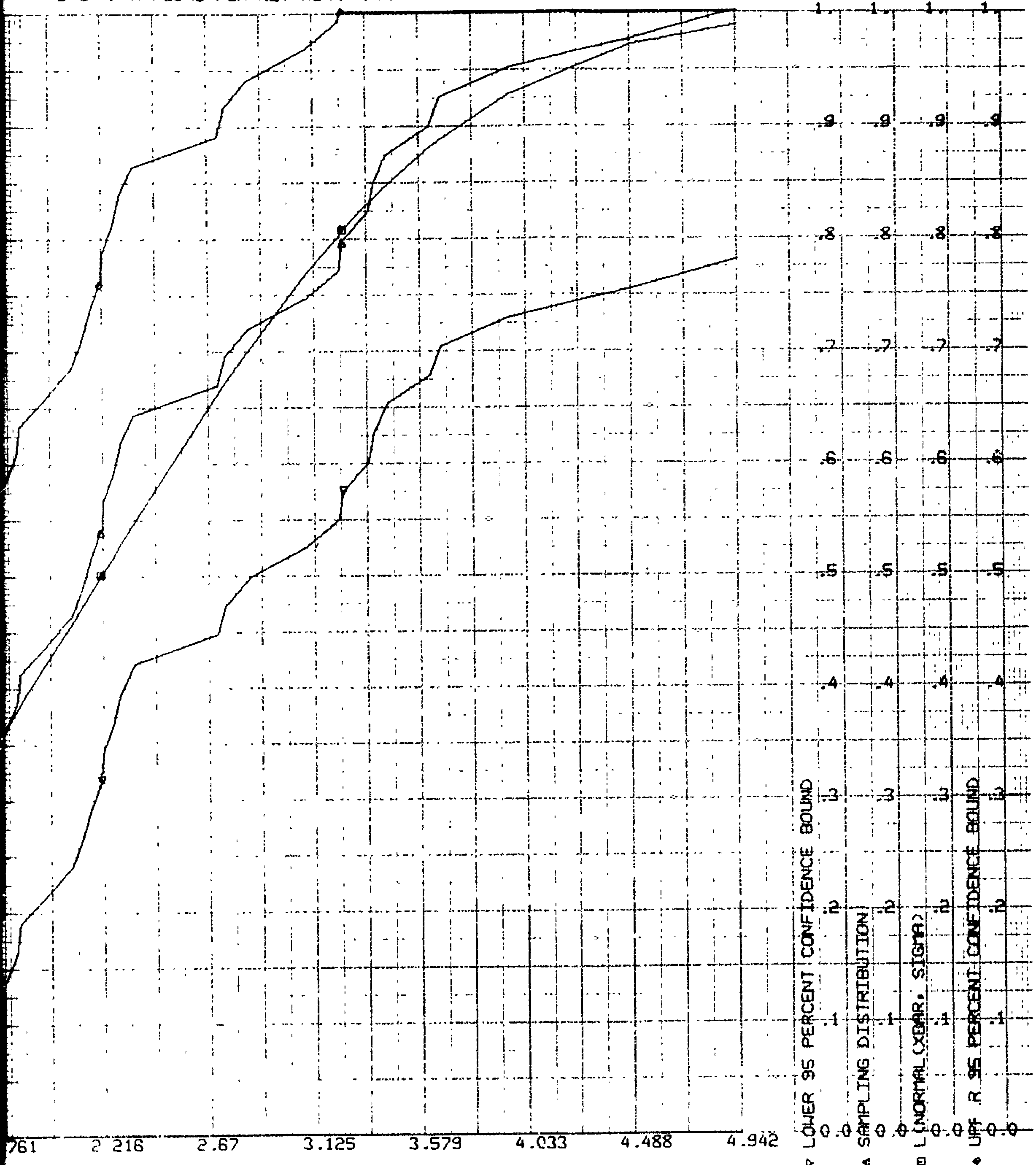


Figure 12 (cont)
Distribution of Maintenance Events
Autopilot

(Shop Man-Hours)

SHOP MAN HOURS FOR KEY WORK UNIT CODE 52A **************



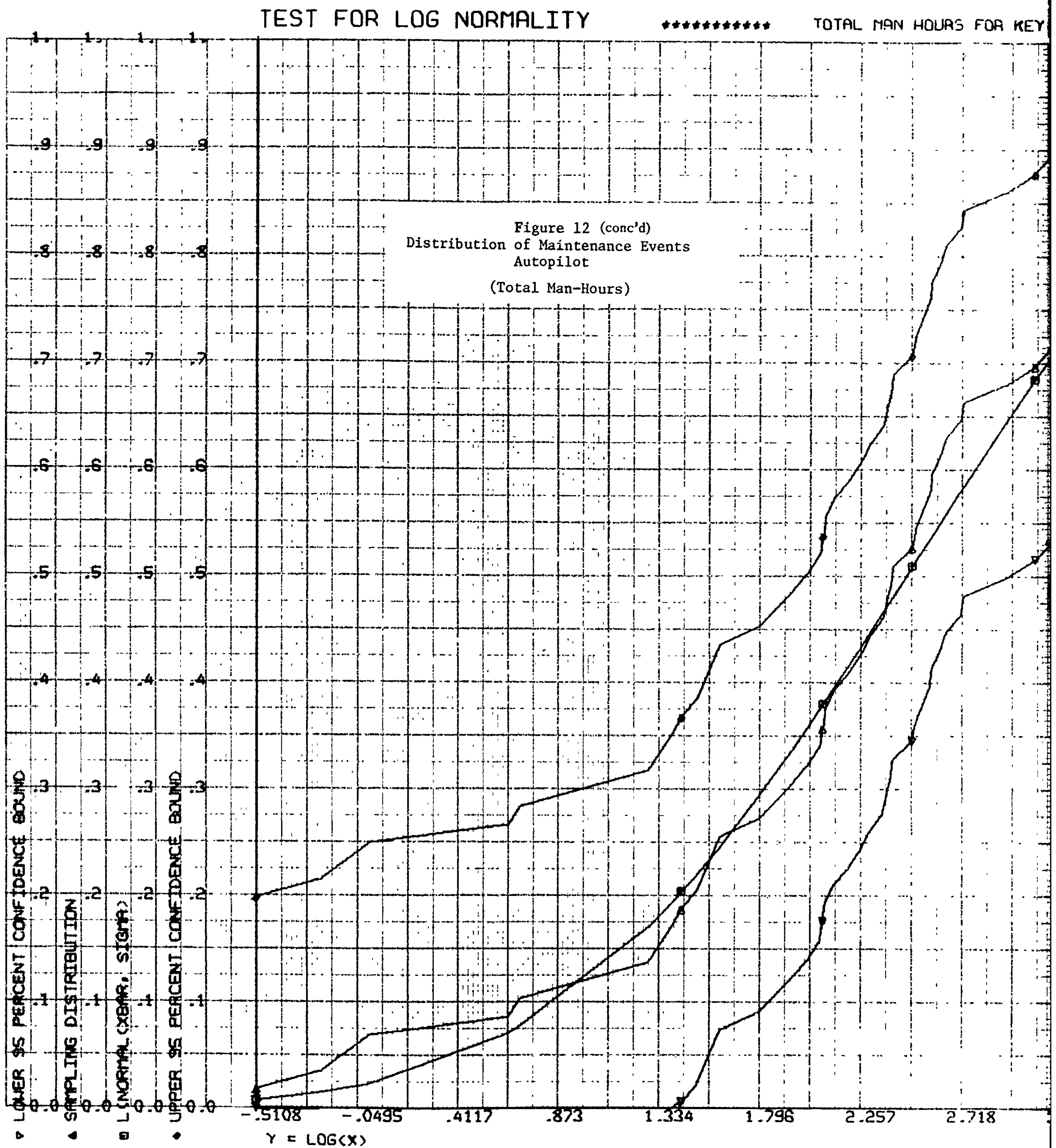
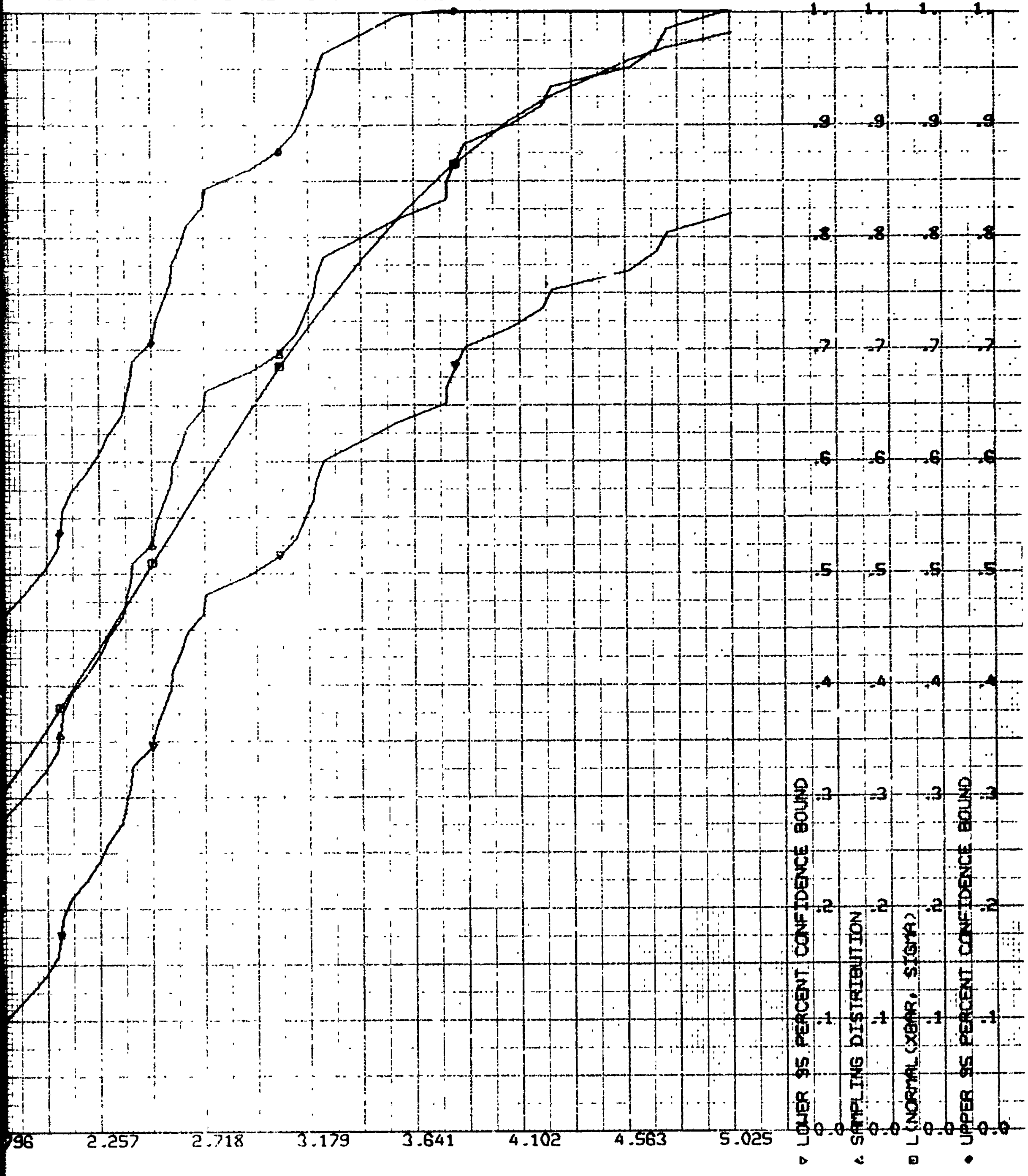
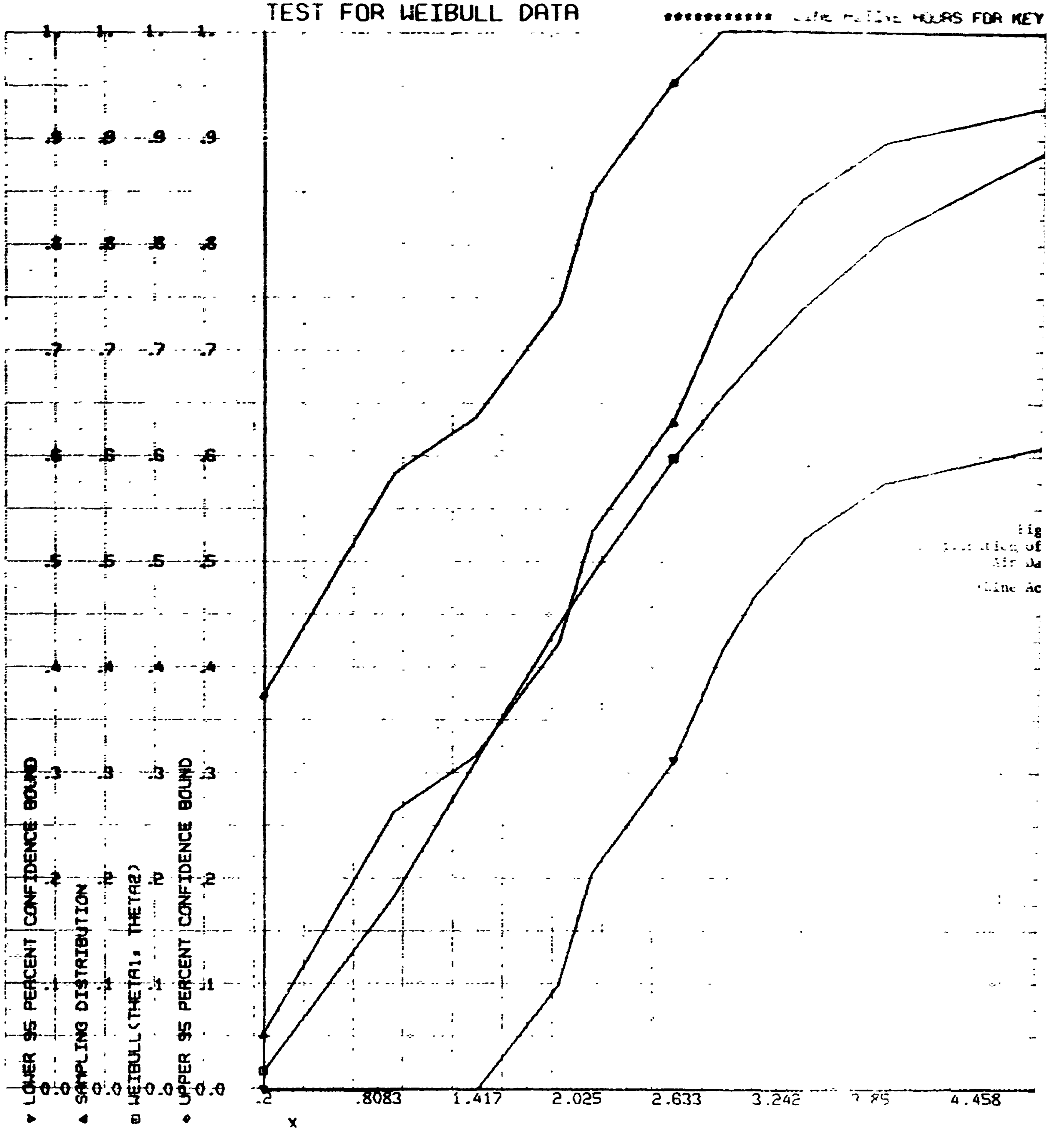


Figure 12 (conc'd)
Distribution of Maintenance Events
Autopilot

(Total Man-Hours)

TOTAL MAN HOURS FOR KEY WORK UNIT CODE 52A ••••••••••••••




TEST FOR WEIBULL DATA
LOWER 95 PERCENT CONFIDENCE BOUND
SAMPLING DISTRIBUTION
WEIBULL(THETA1, THETA2)
UPPER 95 PERCENT CONFIDENCE BOUND
.2
.8083
1.417
2.025
2.633
3.242
4.458
X

1

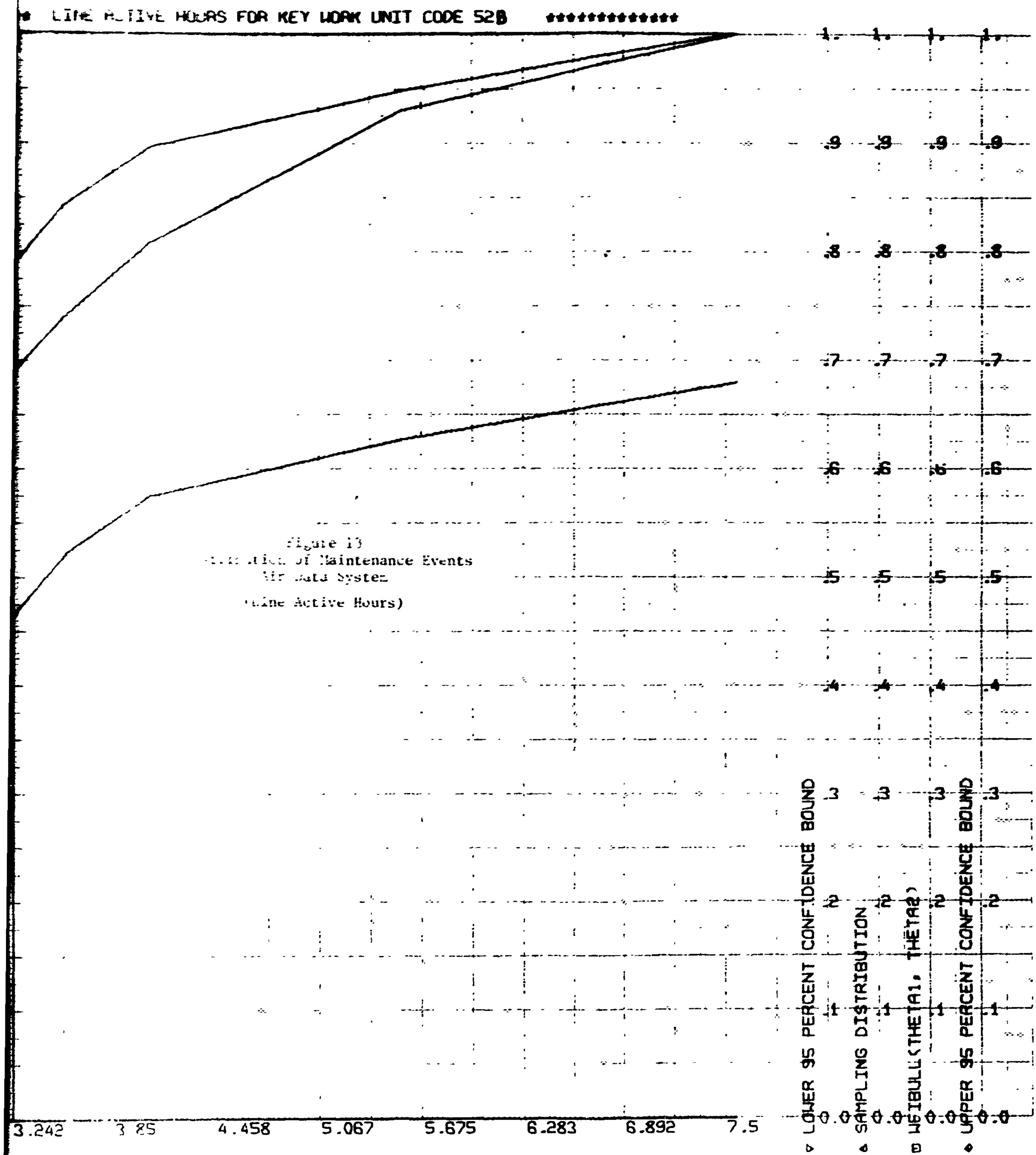
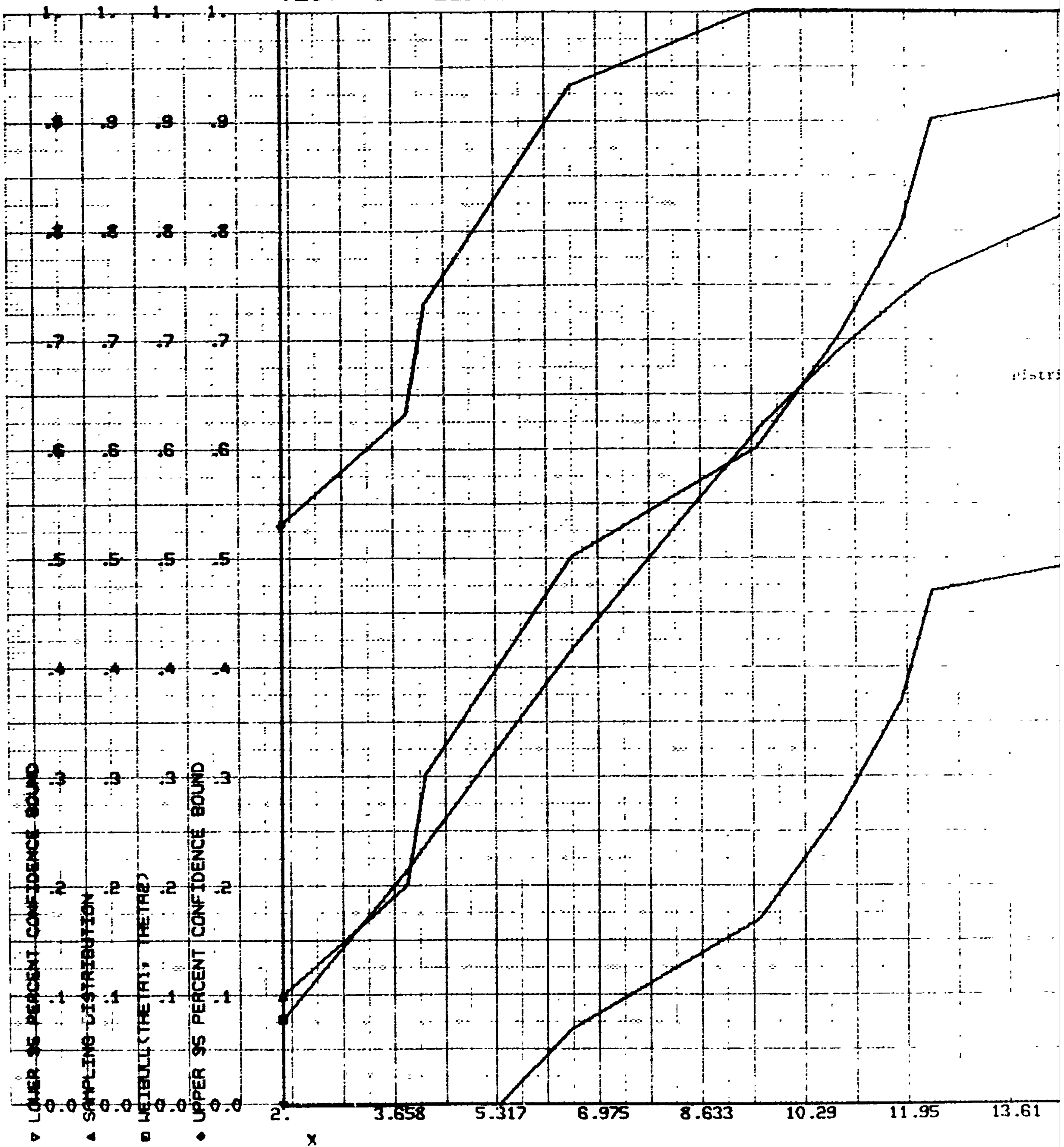


Figure 13
Distribution of Maintenance Events
Air Data System
(Line Active Hours)

TEST FOR WEIBULL DATA ************ SHOP ACTIVE HOURS FOR K



1

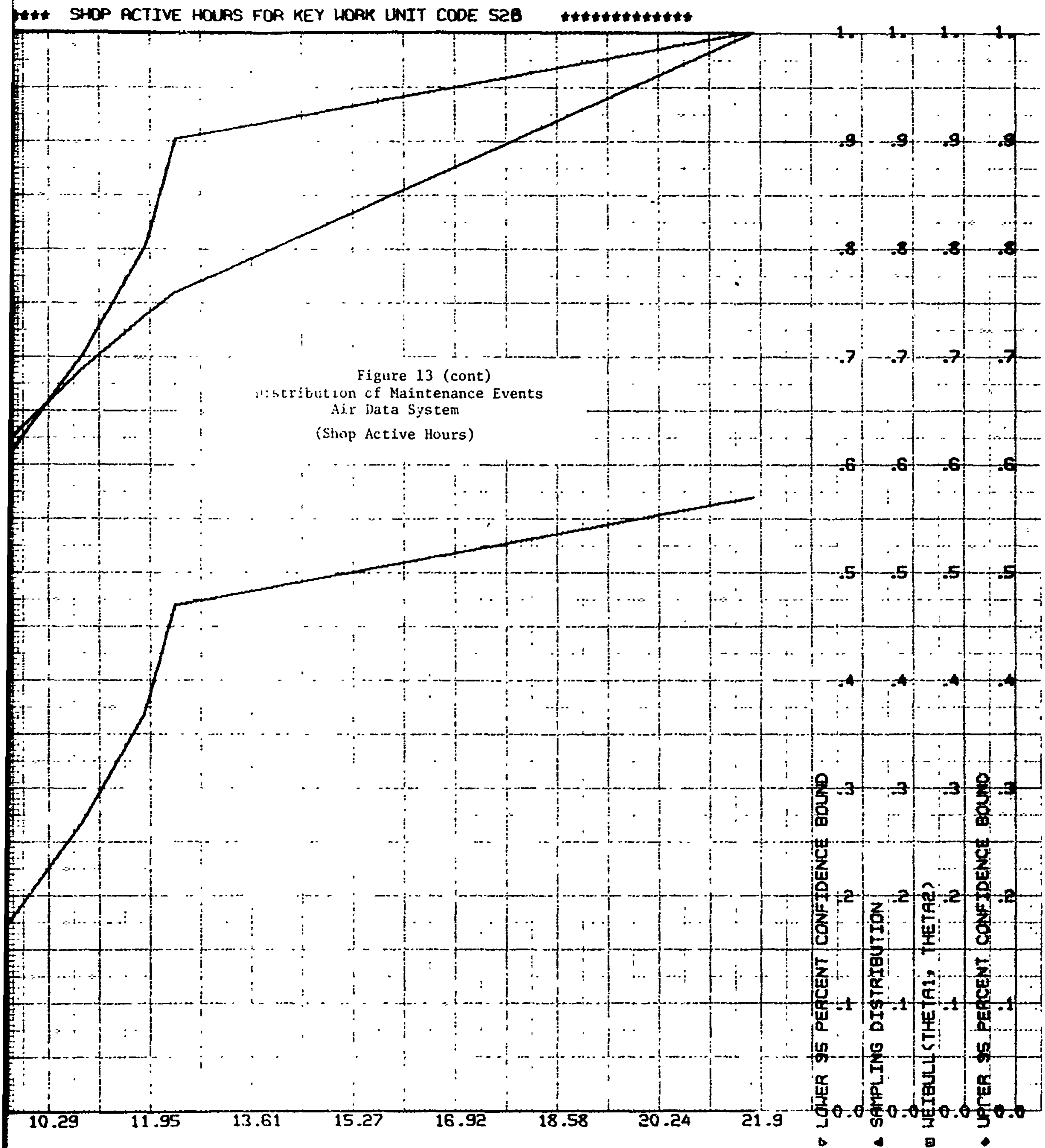
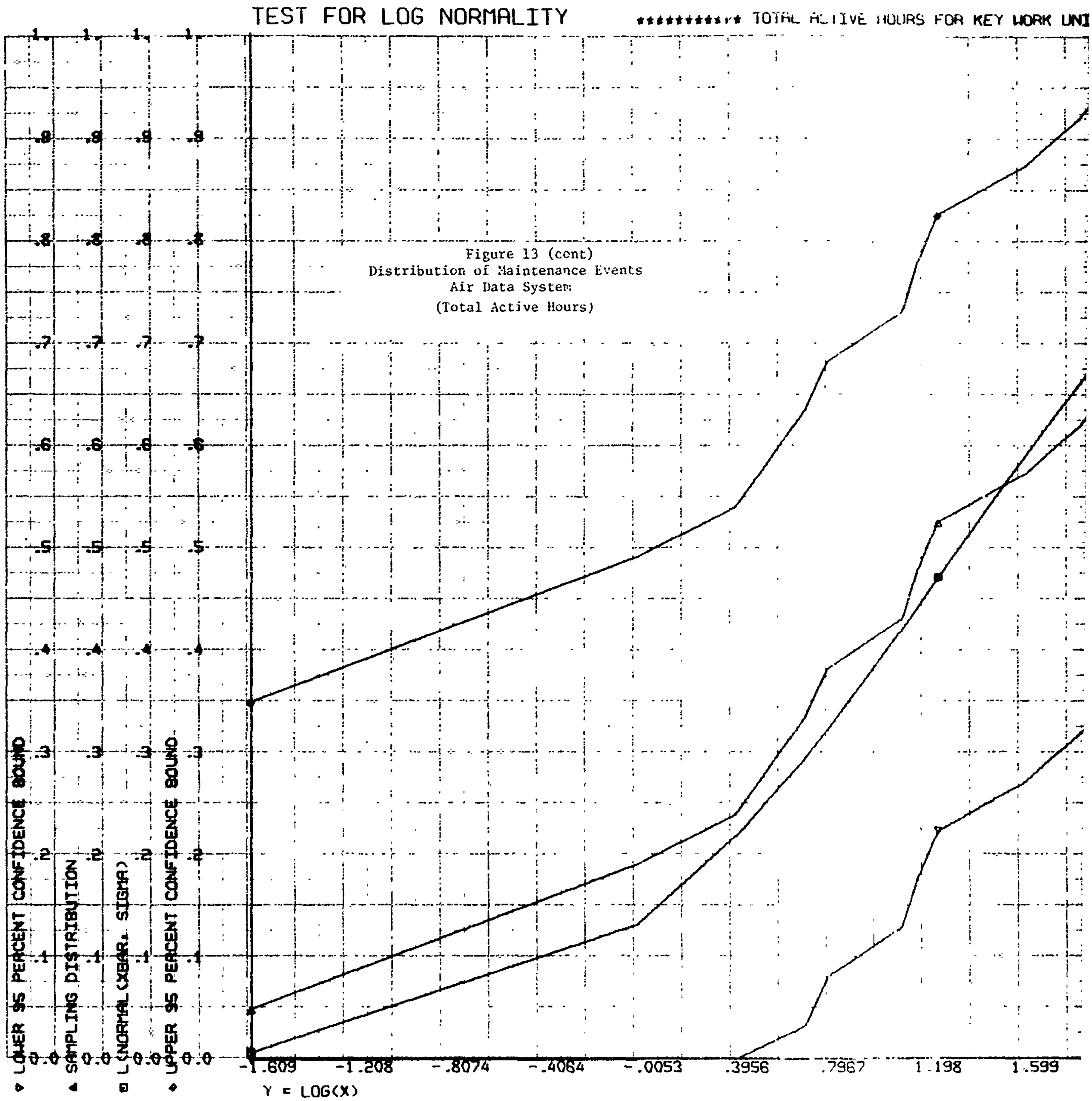
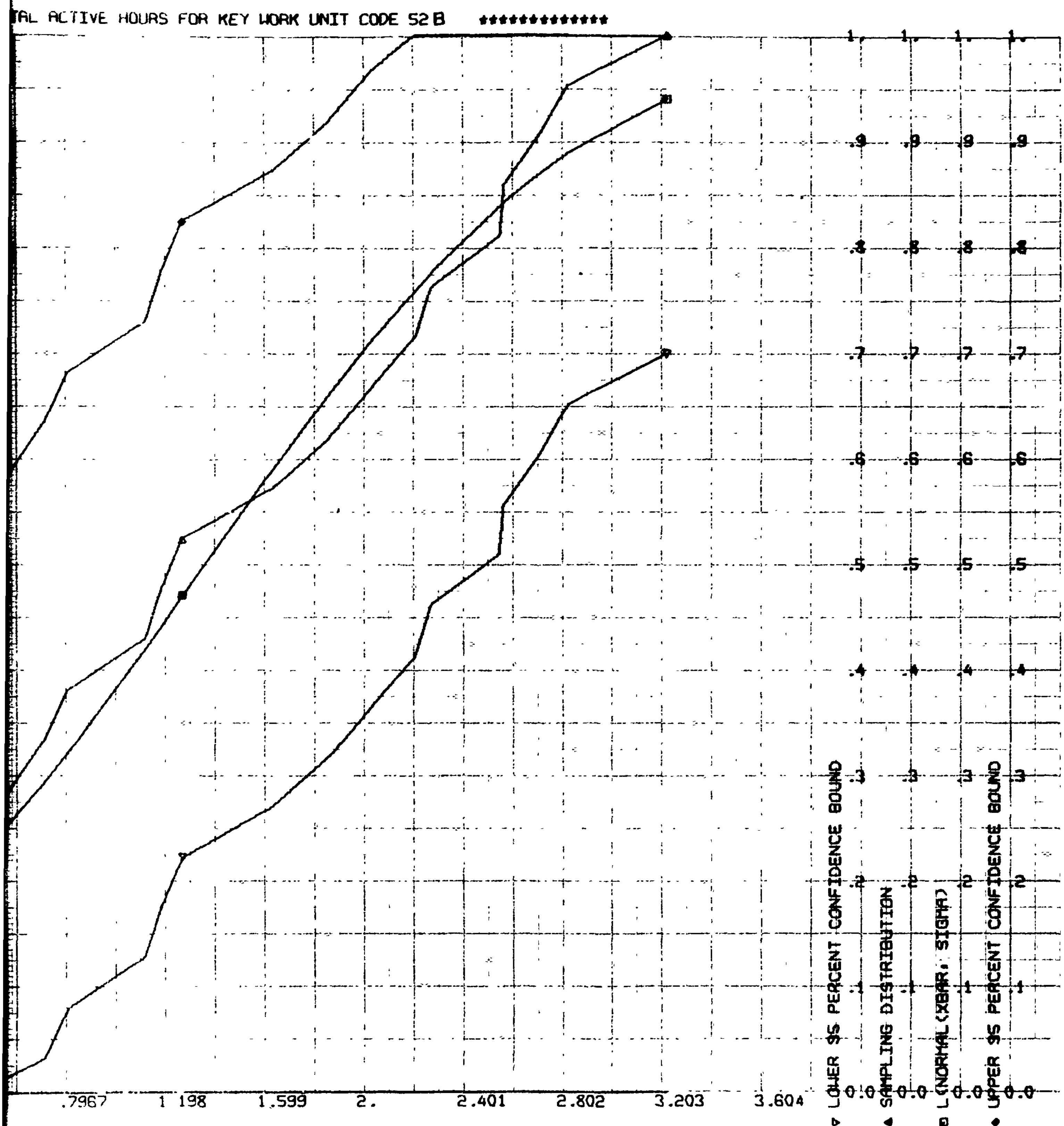
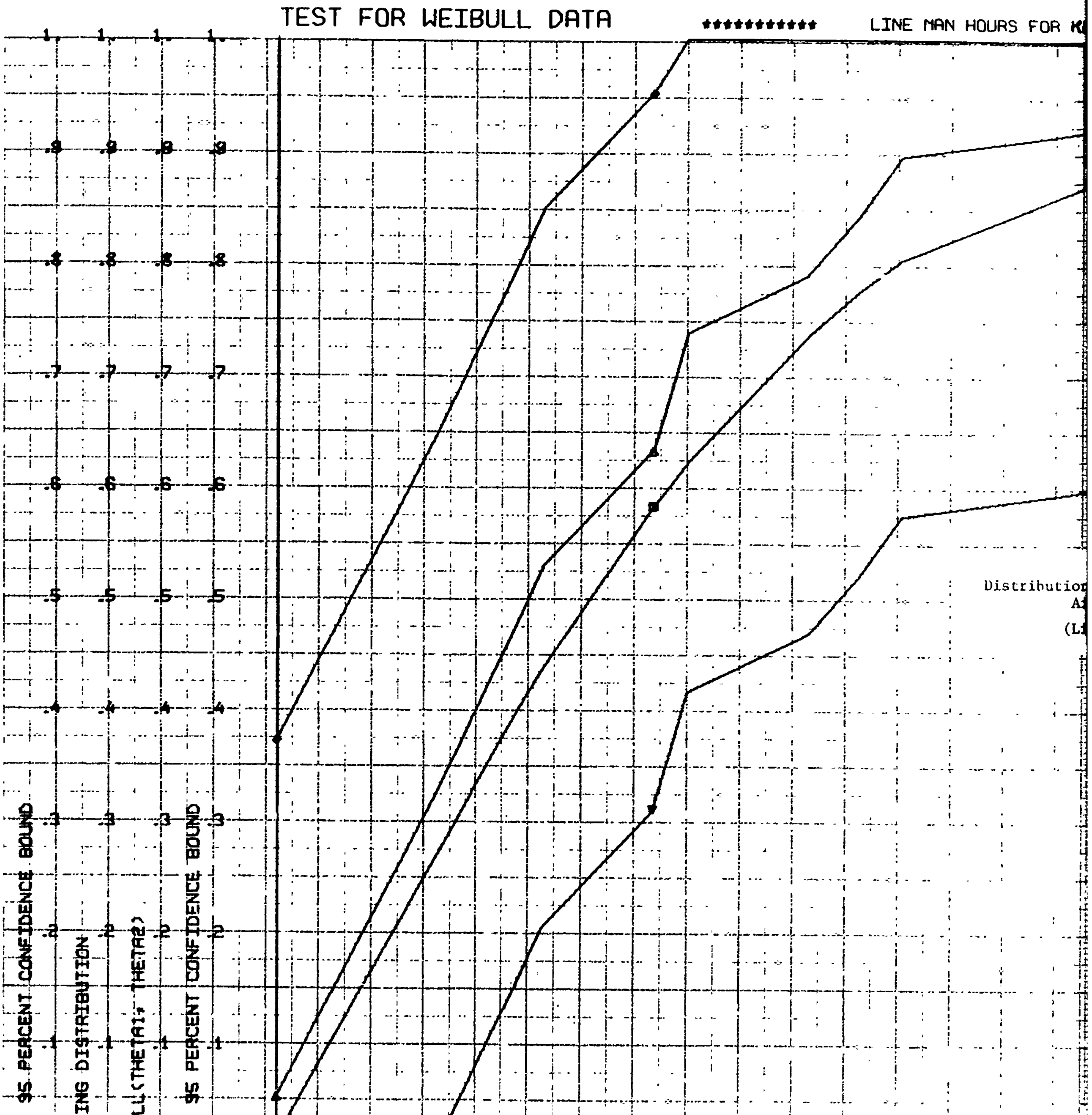


Figure 13 (cont)
Distribution of Maintenance Events
Air Data System
(Shop Active Hours)



TEST FOR LOG NORMALITY
TOTAL ACTIVE HOURS FOR KEY WORK UNI
Figure 13 (cont)
Distribution of Maintenance Events
Air Data System
(Total Active Hours)
LOWER 95 PERCENT CONFIDENCE BOUND
SAMPLING DISTRIBUTION
L(NORMAL(XBAR, SIGMA)
UPPER 95 PERCENT CONFIDENCE BOUND
-1.609
-1.208
-.8074
-.4064
-.0053
.3956
.7967
1.198
1.599
Y = LOG(X)


TAL ACTIVE HOURS FOR KEY WORK UNIT CODE 52B **************
.7967
1.198
1.599
2.
2.401
2.802
3.203
3.604
LOWER 95 PERCENT CONFIDENCE BOUND
SAMPLING DISTRIBUTION
L(NORMAL(XBAR, SIGMA)
UPPER 95 PERCENT CONFIDENCE BOUND


TEST FOR WEIBULL DATA
************ LINE MAN HOURS FOR K
Distributio
A
(L
LOWER 95 PERCENT CONFIDENCE BOUND
SAMPLING DISTRIBUTION
WEIBULL(THETA1, THETA2)
UPPER 95 PERCENT CONFIDENCE BOUND
.2
1.433
2.667
3.9
5.133
6.367
7.6
8.833
X

LINE MAN HOURS FOR KEY WORK UNIT CODE 52B **************

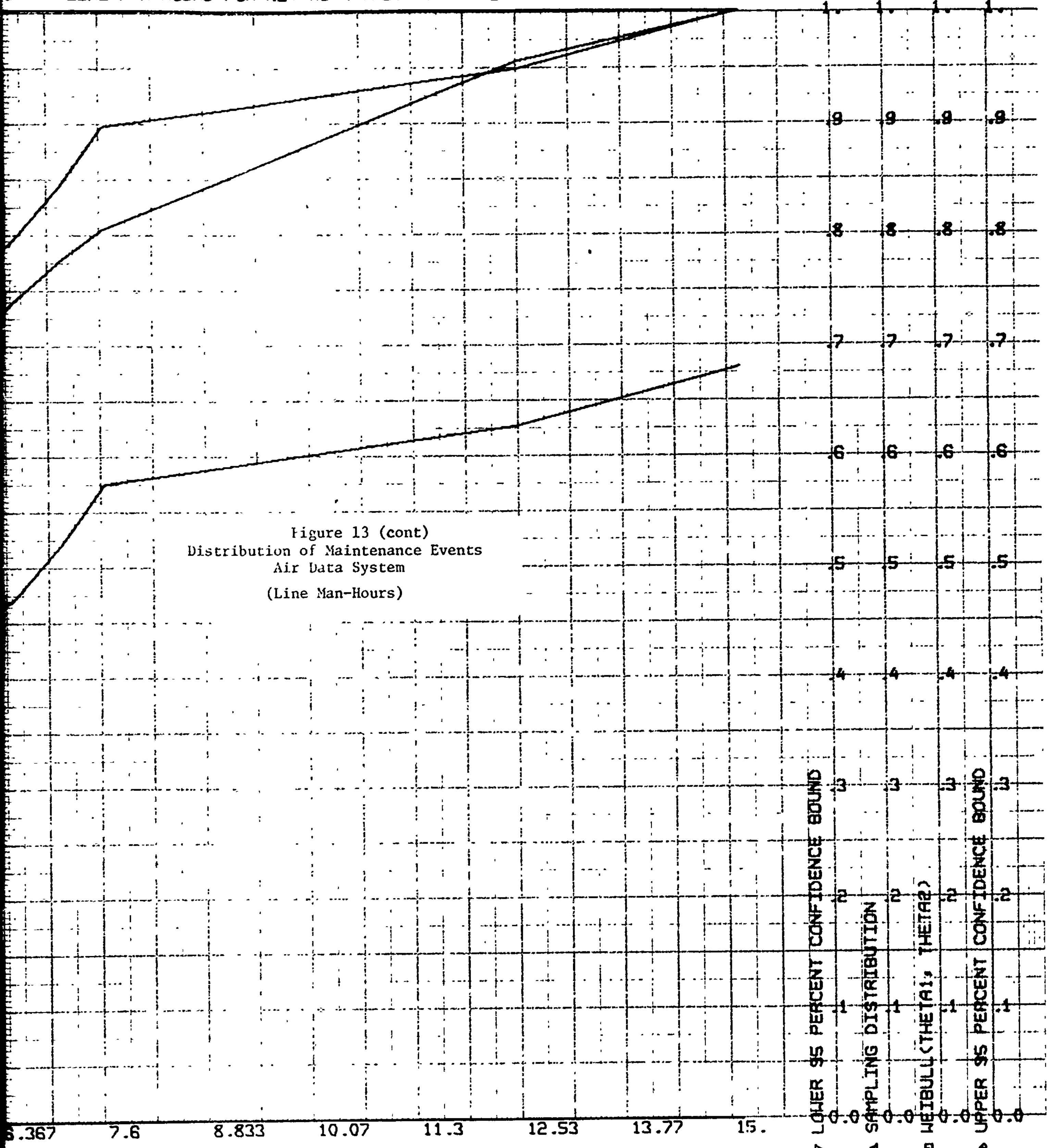


Figure 13 (cont)
Distribution of Maintenance Events
Air Data System

(Line Man-Hours)

TEST FOR WEIBULL DATA

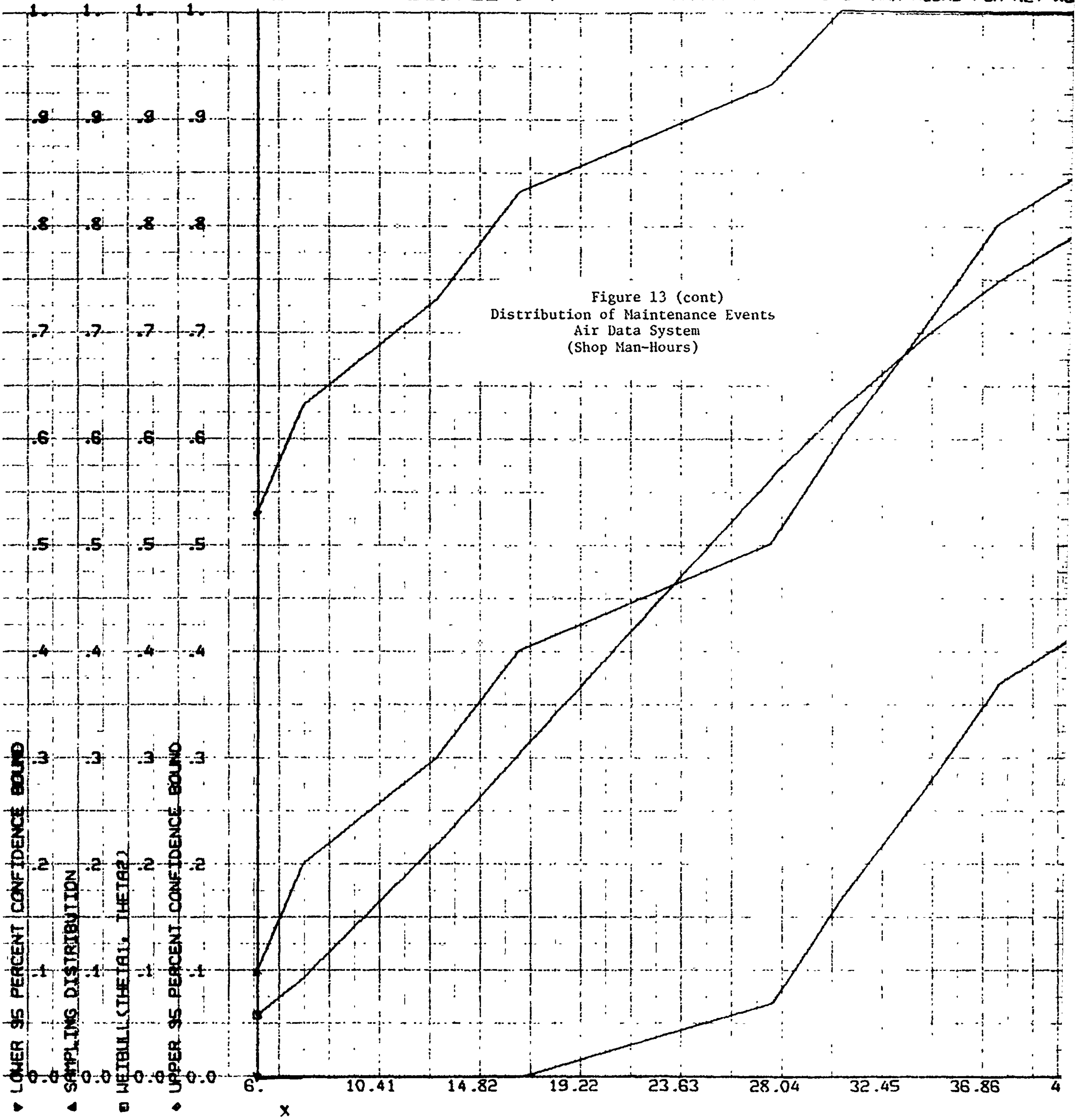
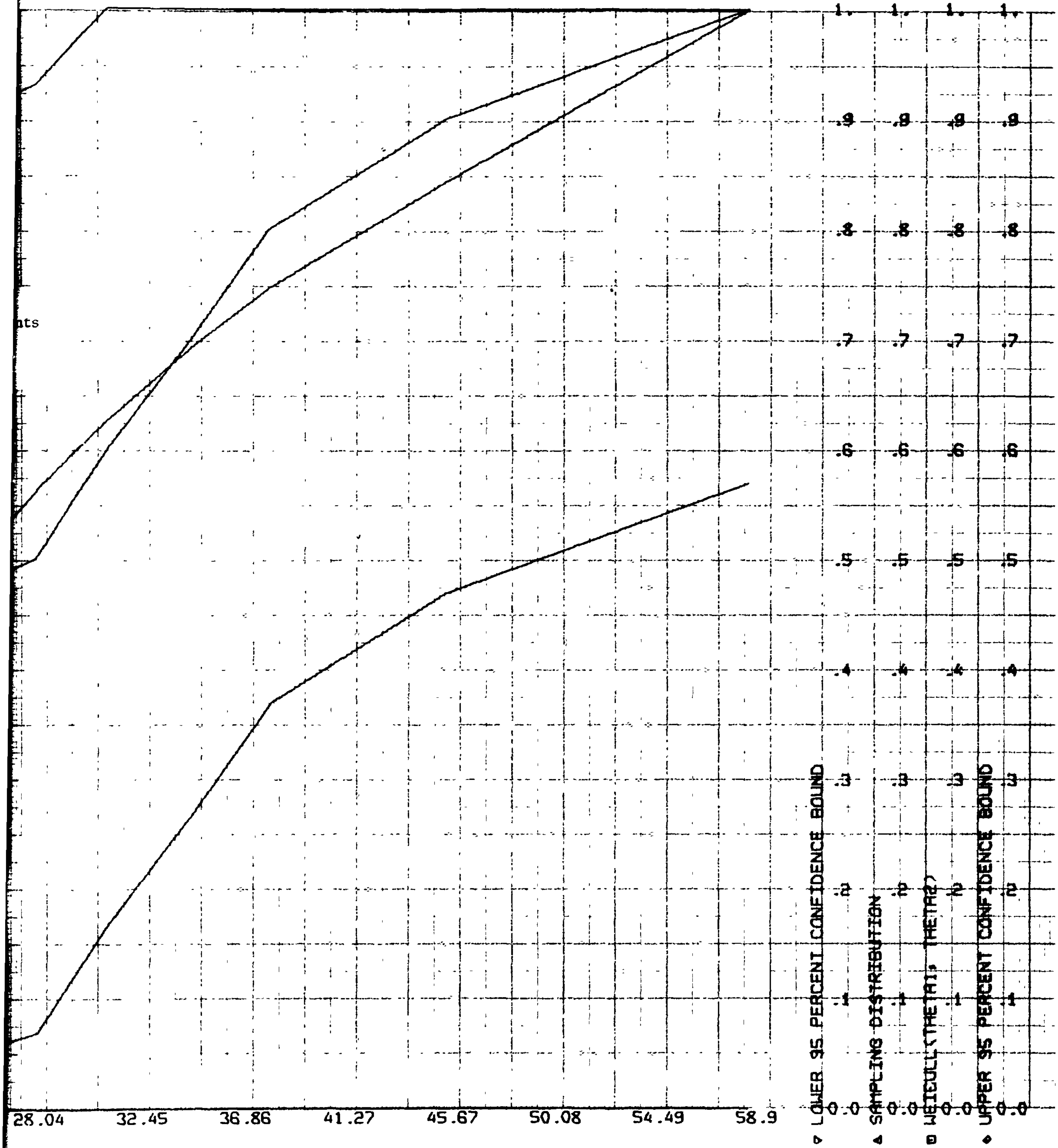


Figure 13 (cont)
Distribution of Maintenance Events
Air Data System
(Shop Man-Hours)

** SHOP MAN HOURS FOR KEY WORK UNIT CODE 52B **************



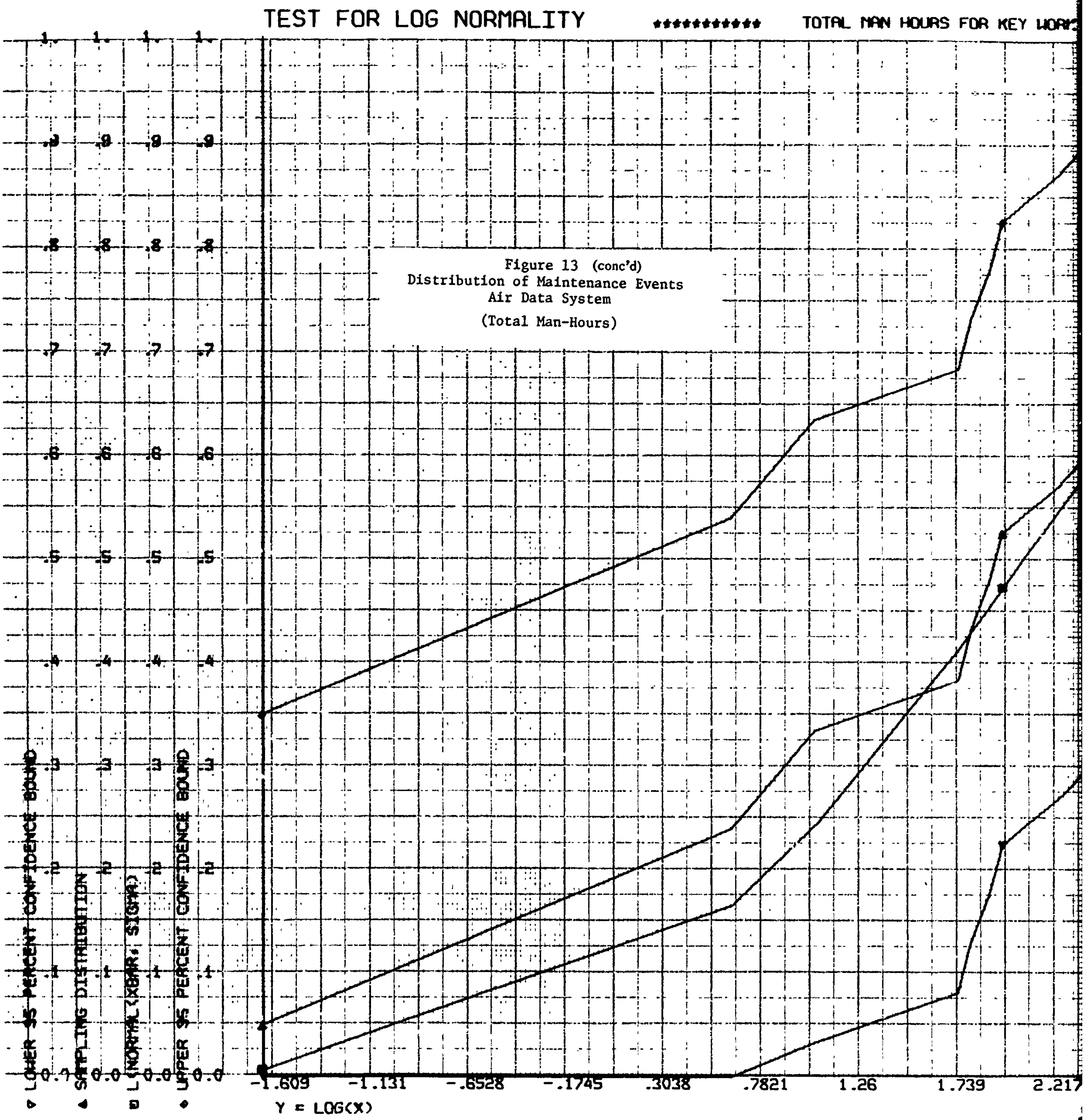
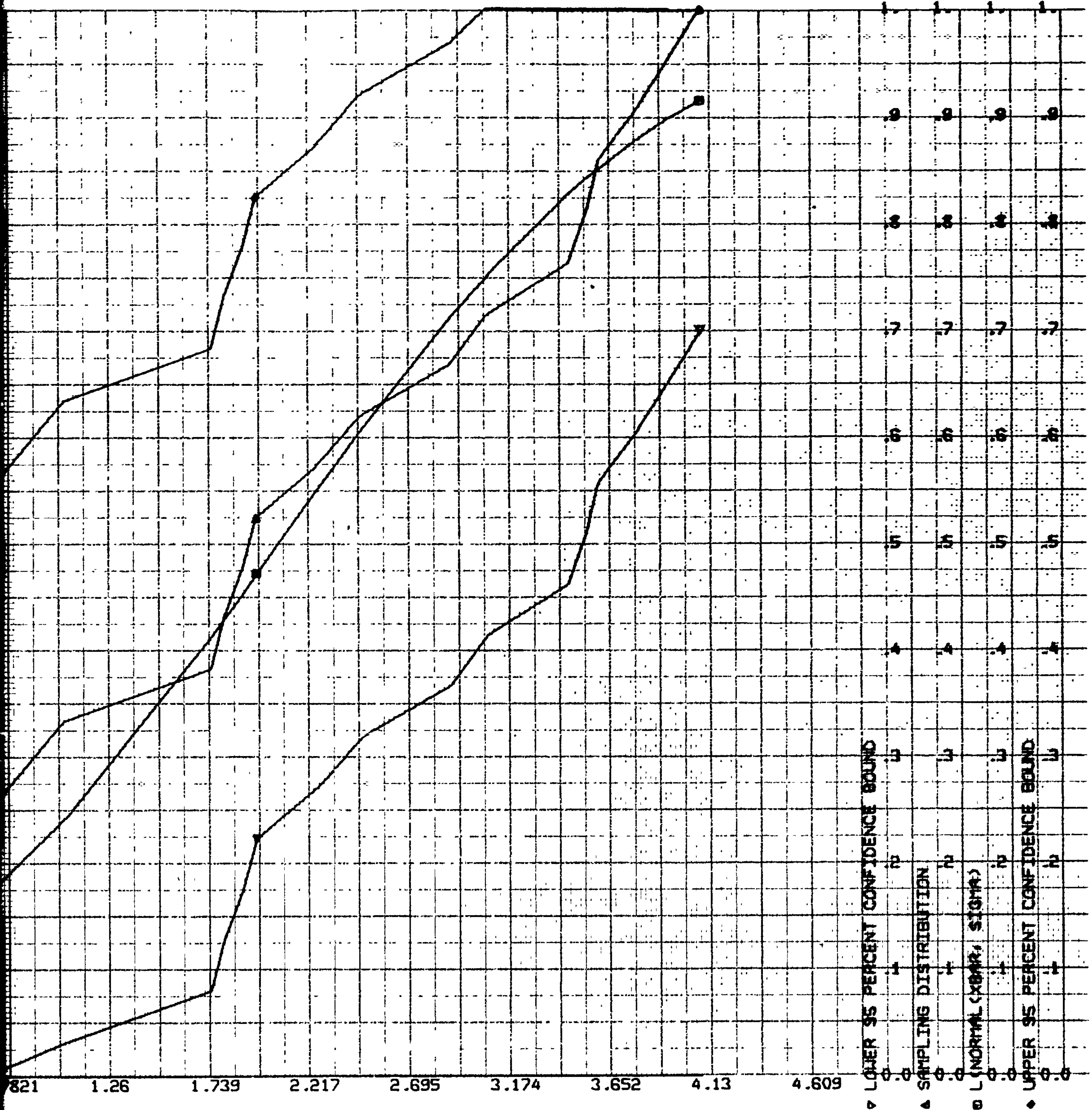
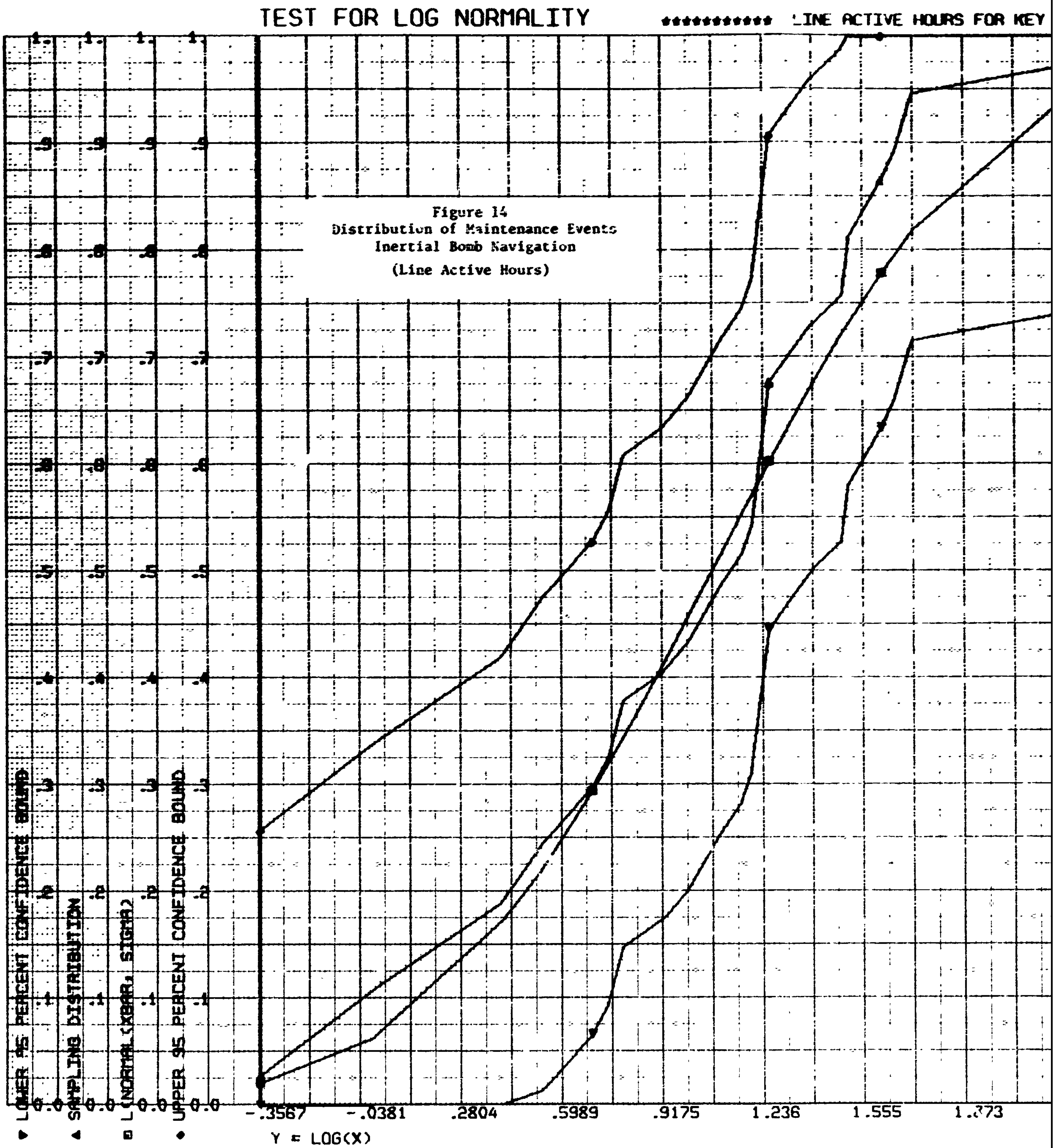


Figure 13 (conc'd)
Distribution of Maintenance Events
Air Data System
(Total Man-Hours)

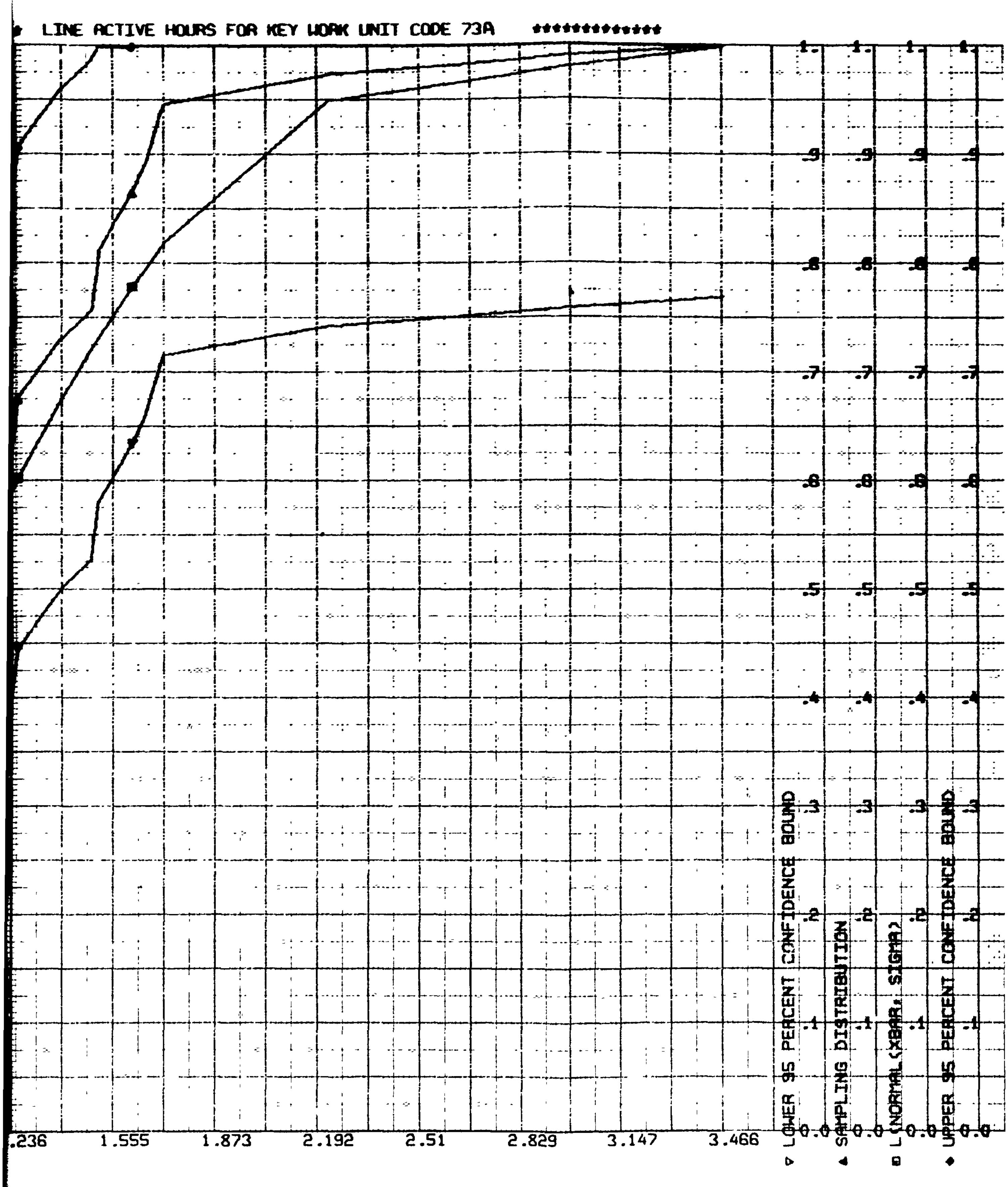
TOTAL MAN HOURS FOR KEY WORK UNIT CODE 52B **************



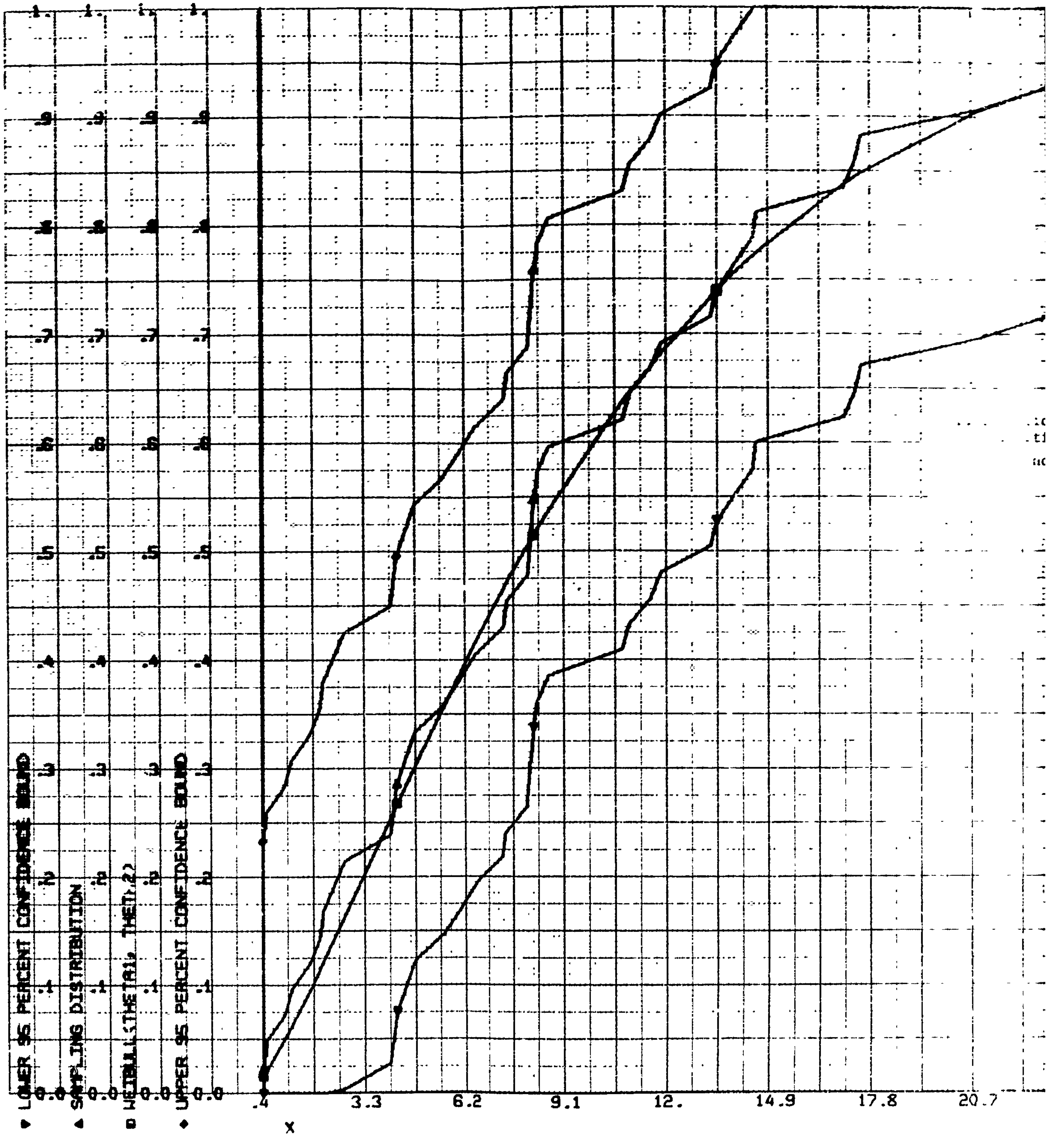


TEST FOR LOG NORMALITY
************ LINE ACTIVE HOURS FOR KEY
Figure 14
Distribution of Maintenance Events
Inertial Bomb Navigation
(Line Active Hours)
LOWER 95 PERCENT CONFIDENCE BOUND
SAMPLING DISTRIBUTION
L(NORMAL(XBAR, SIGMA)
UPPER 95 PERCENT CONFIDENCE BOUND
-.3567
-.0381
.2804
.5989
.9175
1.236
1.555
Y = LOG(X)

1


LINE ACTIVE HOURS FOR KEY WORK UNIT CODE 73A *************
.236
1.555
1.873
2.192
2.51
2.829
3.147
3.466
LOWER 95 PERCENT CONFIDENCE BOUND
SAMPLING DISTRIBUTION
L(NORMAL(XBAR, SIGMA)
UPPER 95 PERCENT CONFIDENCE BOUND

TEST FOR WEIBULL DATA ************ SHOP ACTIVE HOURS FOR KE



**** SHOP ACTIVE HOURS FOR KEY WORK UNIT CODE 73A **************

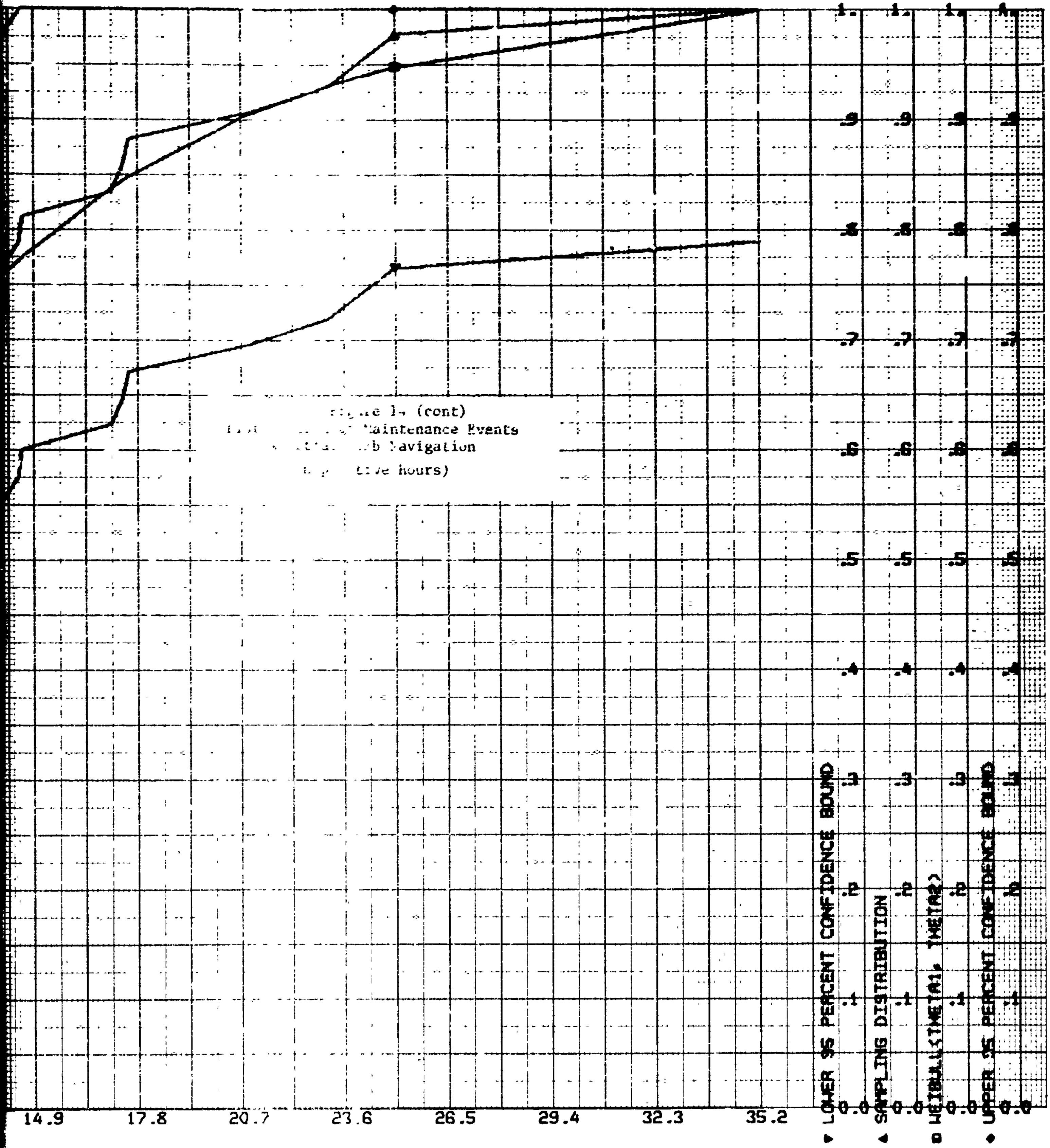
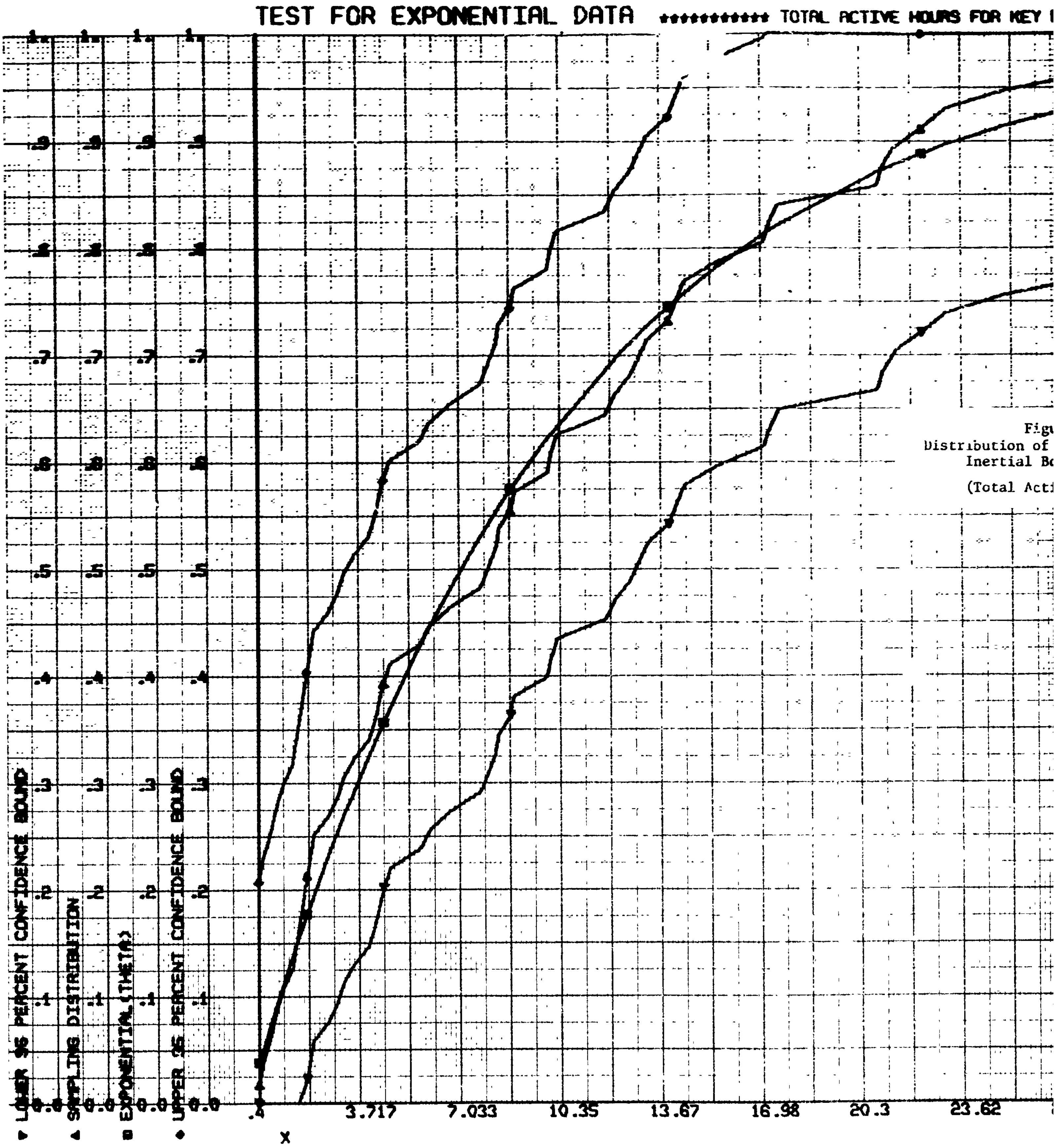


Figure 14 (cont)
Maintenance Events
Navigation
tive hours)



Figu
Distribution of
Inertial Bo

(Total Acti

1

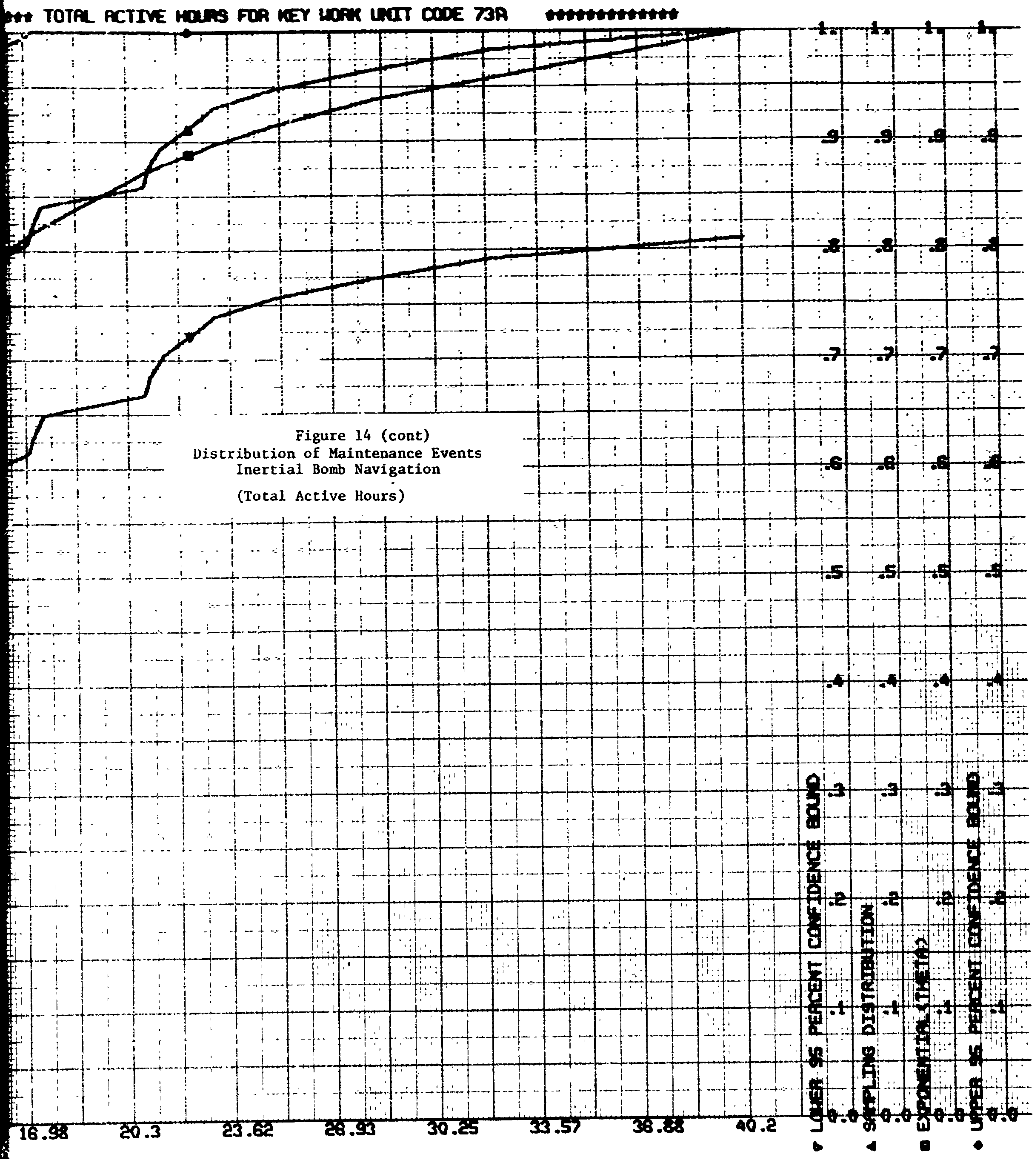


Figure 14 (cont)
Distribution of Maintenance Events
Inertial Bomb Navigation

(Total Active Hours)

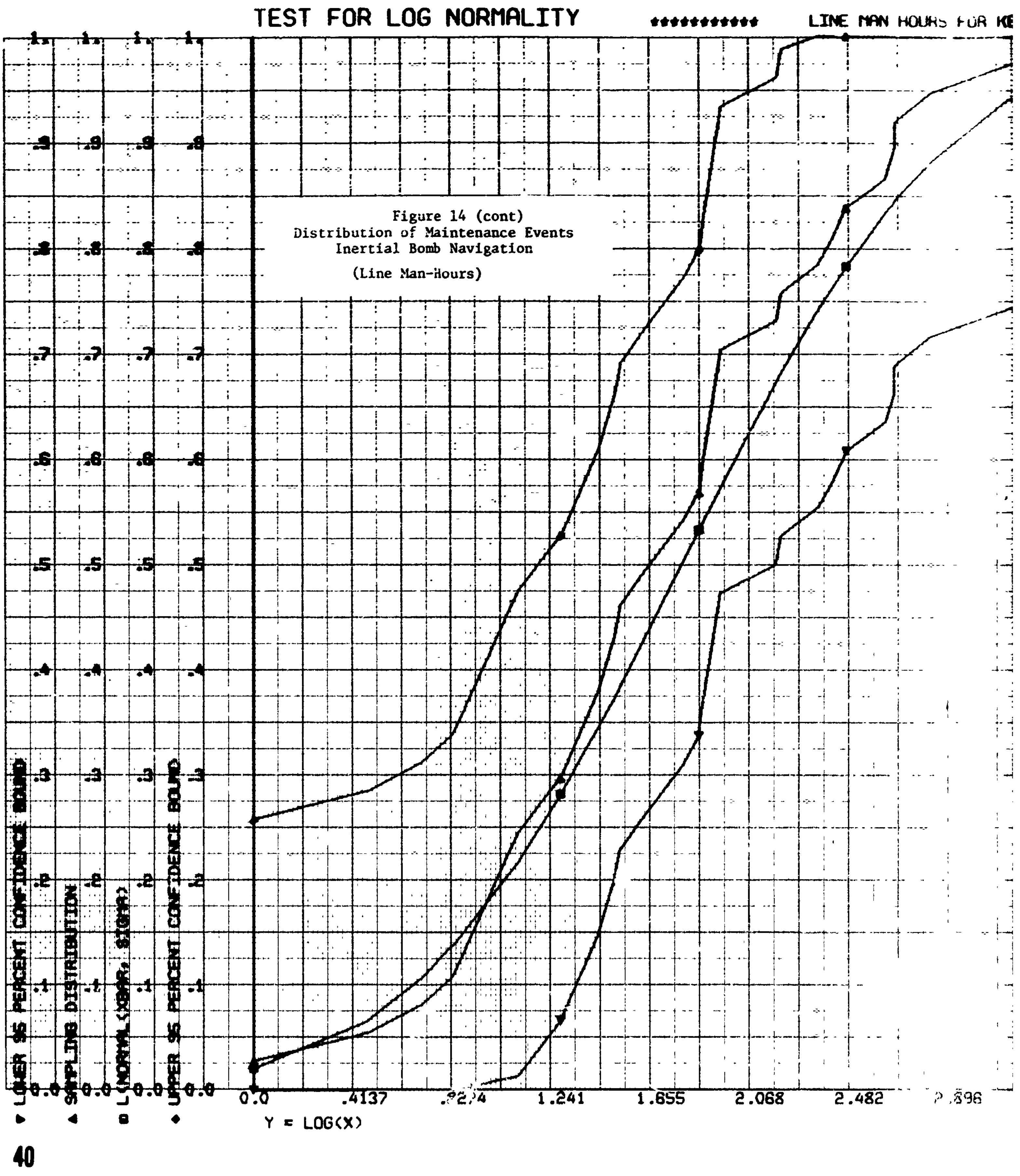
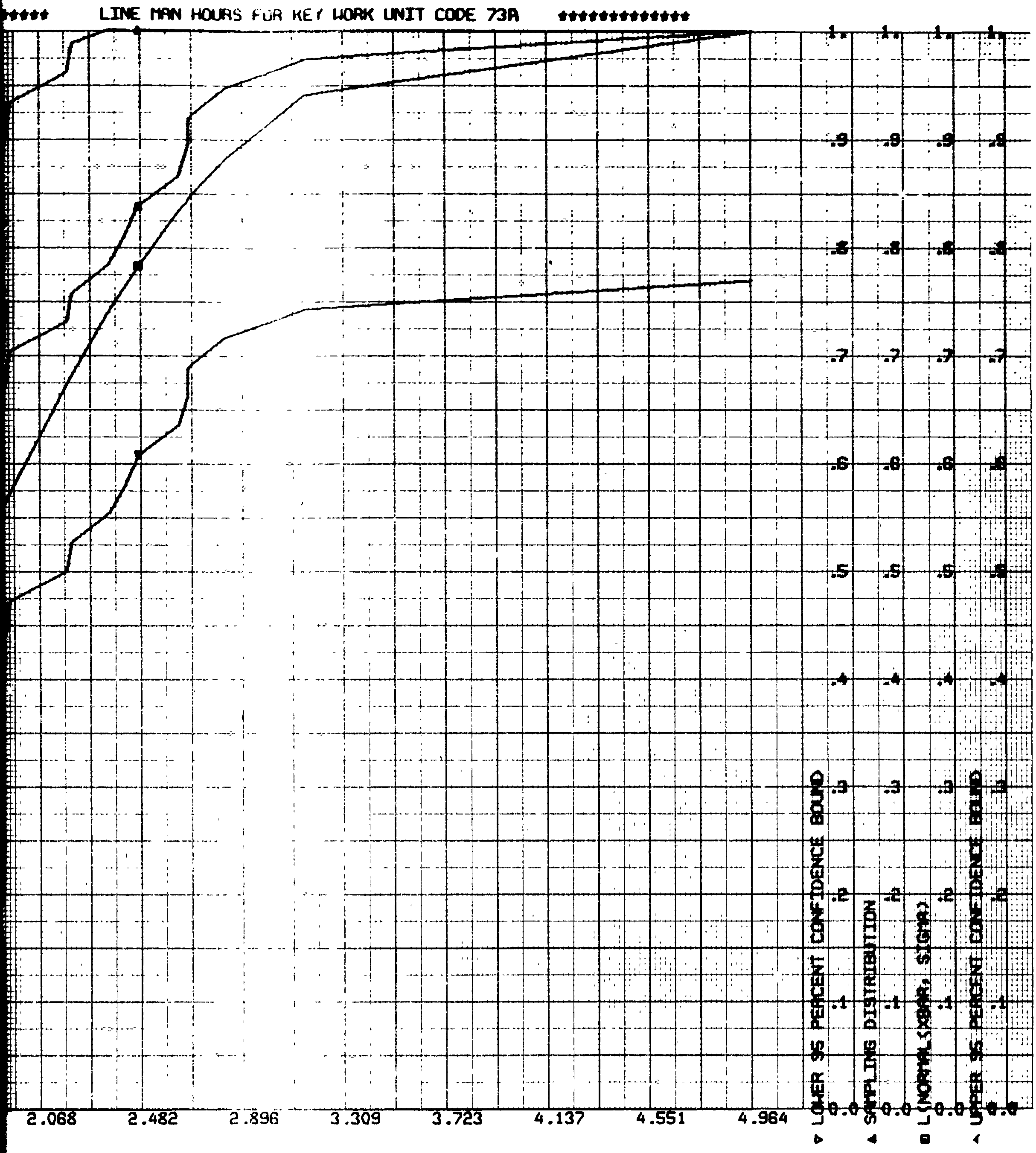


Figure 14 (cont)
Distribution of Maintenance Events
Inertial Bomb Navigation

(Line Man-Hours)


***** LINE MAN HOURS FOR KEY WORK UNIT CODE 73A **************
2.068
2.482
2.896
3.309
3.723
4.137
4.551
4.964
LOWER 95 PERCENT CONFIDENCE BOUND
SAMPLING DISTRIBUTION
L(NORMAL(XBAR, SIGMA))
UPPER 95 PERCENT CONFIDENCE BOUND
1.
.9
.8
.7
.6
.5
.4
.3
.2
.1
0.0

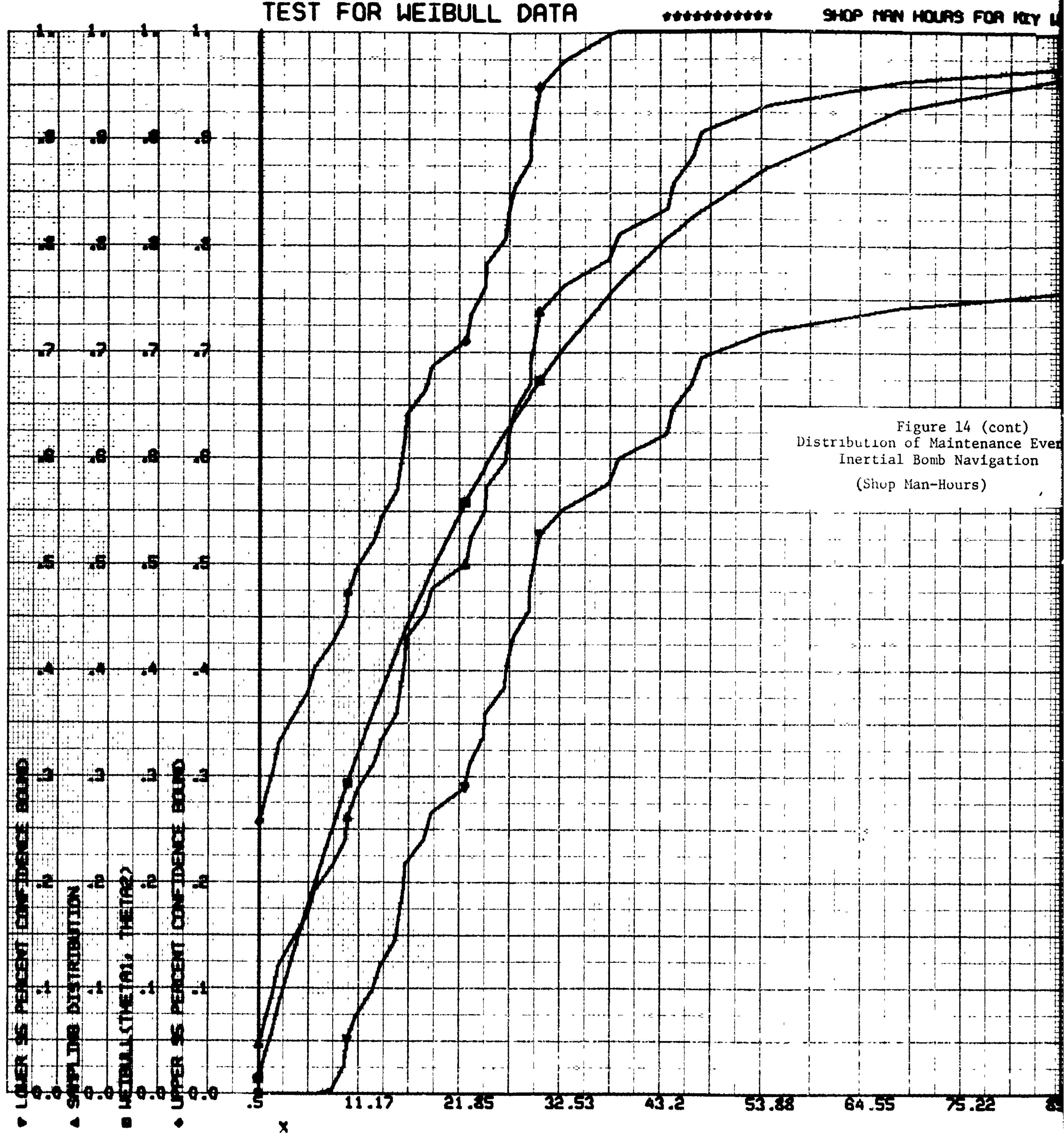


Figure 14 (cont)
Distribution of Maintenance Even
Inertial Bomb Navigation
(Shop Man-Hours)

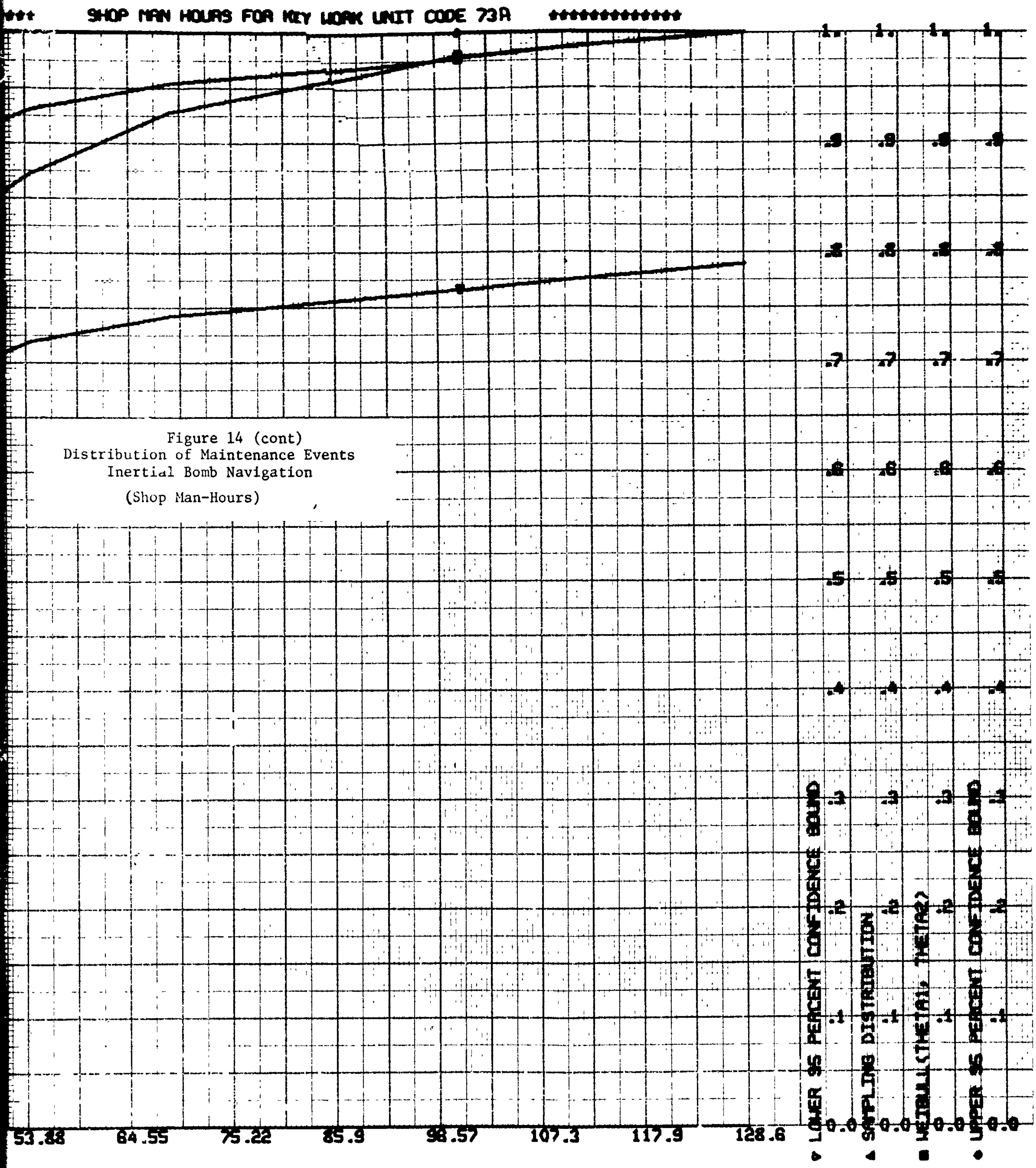
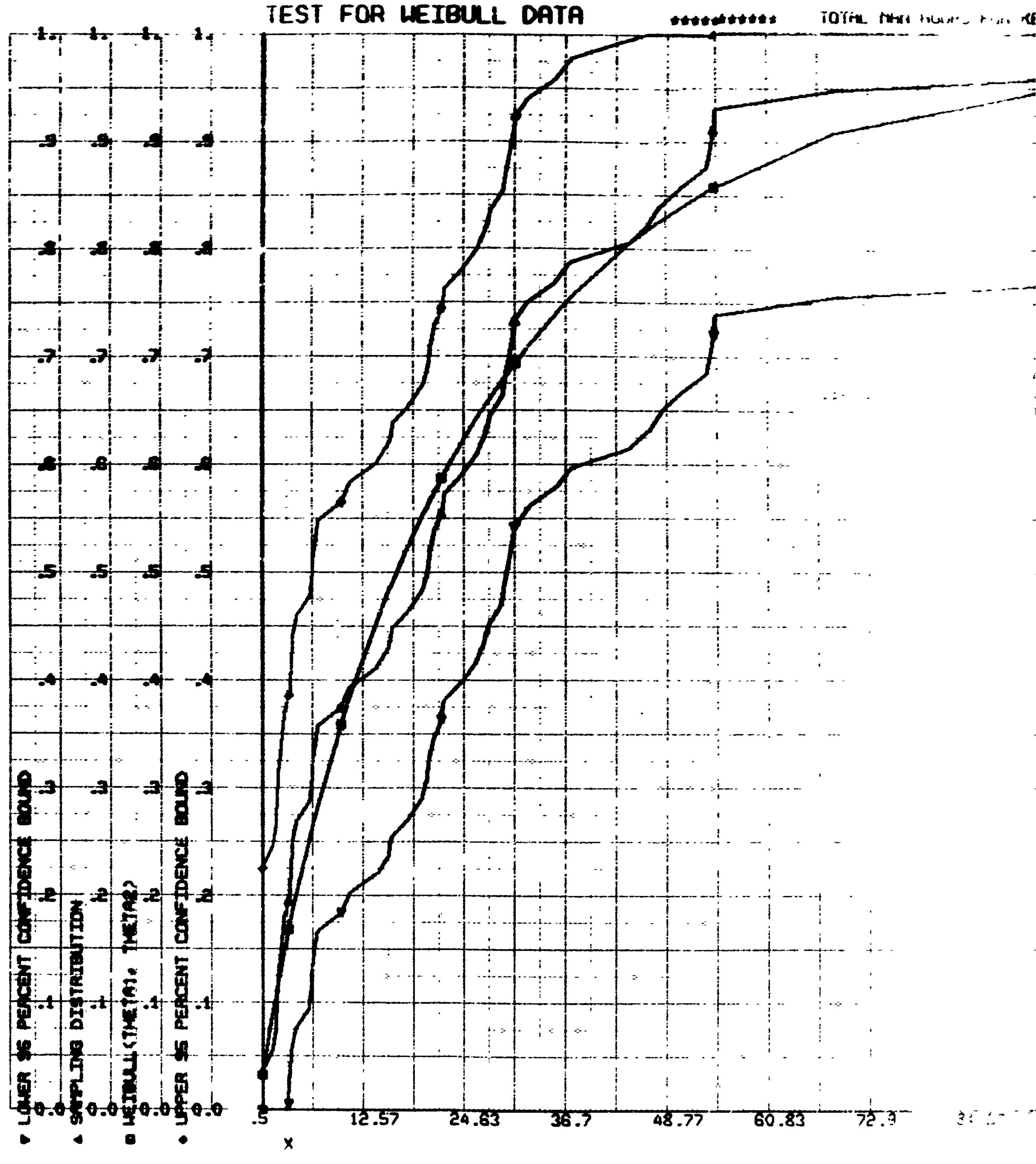
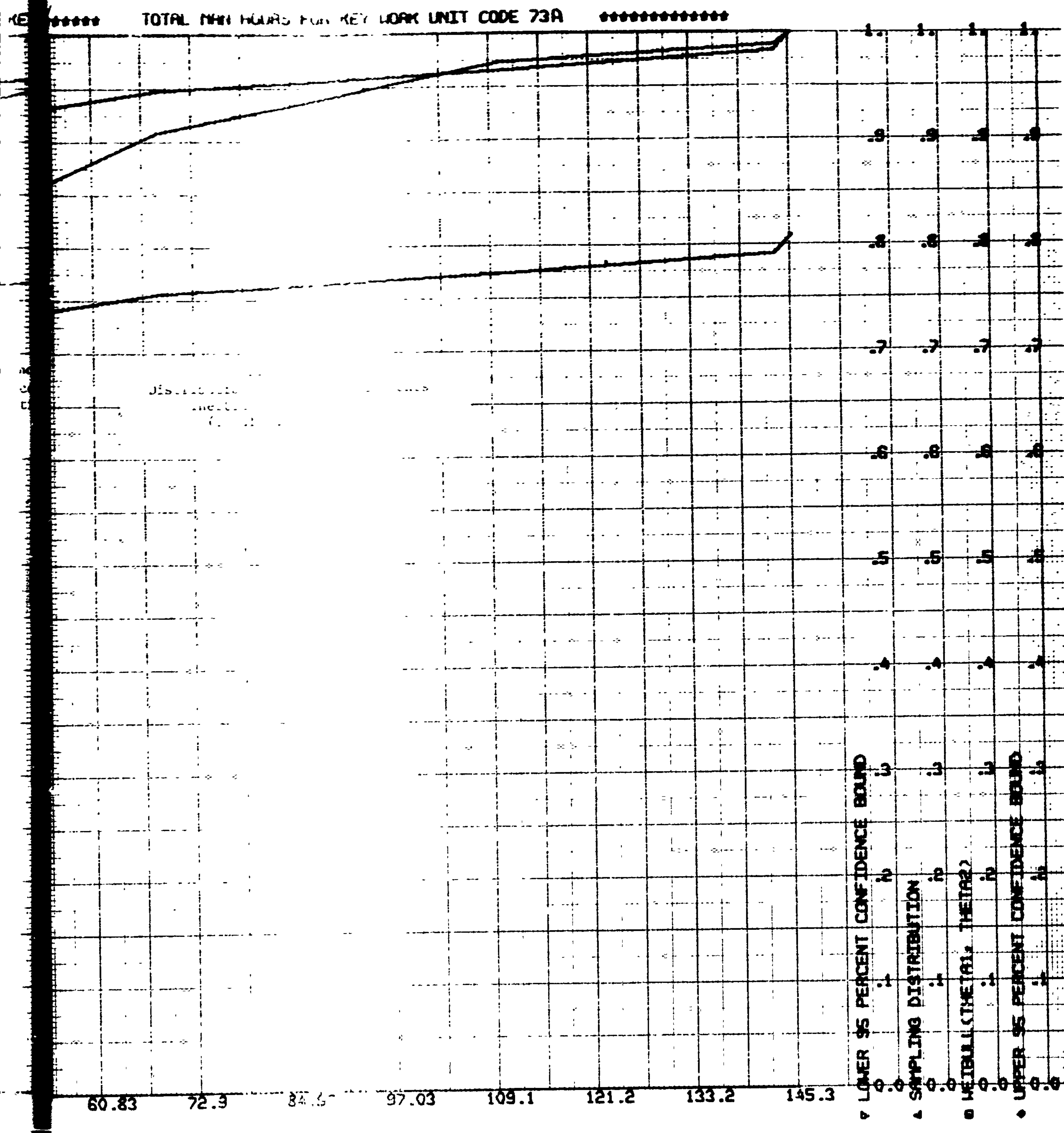
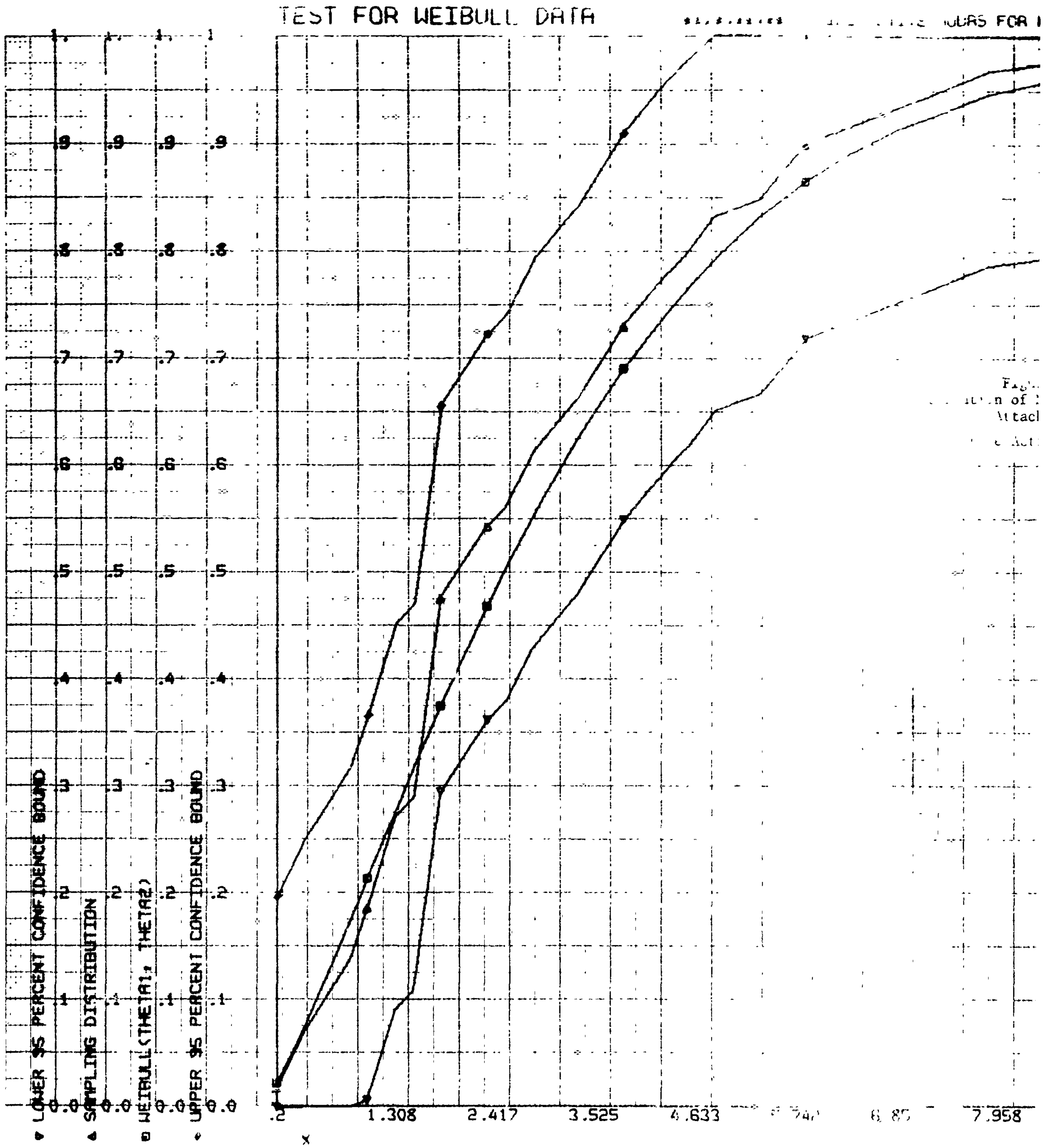


Figure 14 (cont)
Distribution of Maintenance Events
Inertial Bomb Navigation
(Shop Man-Hours)



TEST FOR WEIBULL DATA
TOTAL MAN HOURS
LOWER 95 PERCENT CONFIDENCE BOUND
SAMPLING DISTRIBUTION
WEIBULL(THETA1, THETA2)
UPPER 95 PERCENT CONFIDENCE BOUND
.5
12.57
24.63
36.7
48.77
60.83
72.9
X


TOTAL MAN HOURS FOR KEY WORK UNIT CODE 73A
60.83
72.9
97.03
109.1
121.2
133.2
145.3
LOWER 95 PERCENT CONFIDENCE BOUND
SAMPLING DISTRIBUTION
WEIBULL(THETA1, THETA2)
UPPER 95 PERCENT CONFIDENCE BOUND


TEST FOR WEIBULL DATA
LOWER 95 PERCENT CONFIDENCE BOUND
SAMPLING DISTRIBUTION
WEIBULL(THETA1, THETA2)
UPPER 95 PERCENT CONFIDENCE BOUND
0.0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1
.2
1.308
2.417
3.525
4.633
7.958
X

1

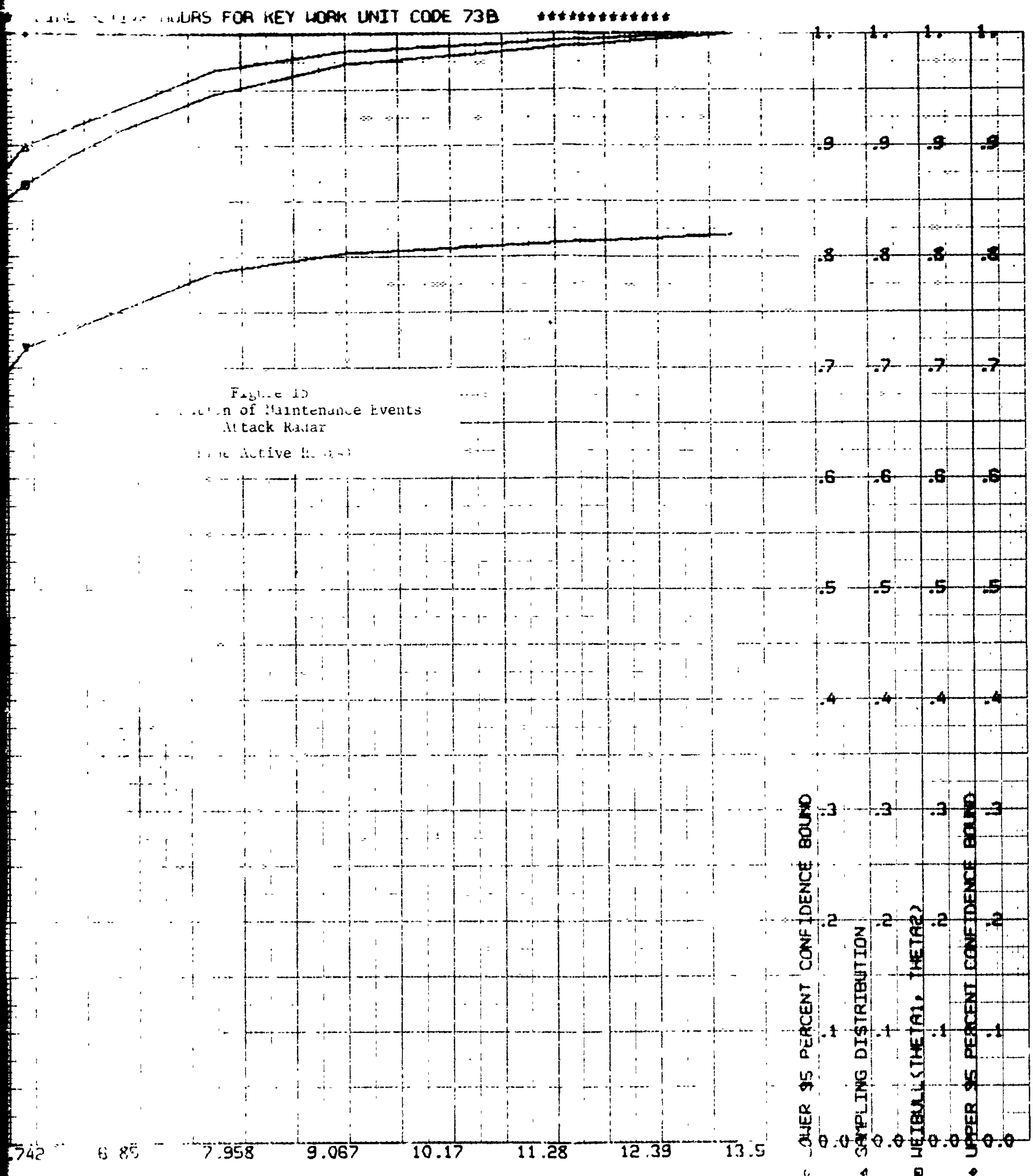
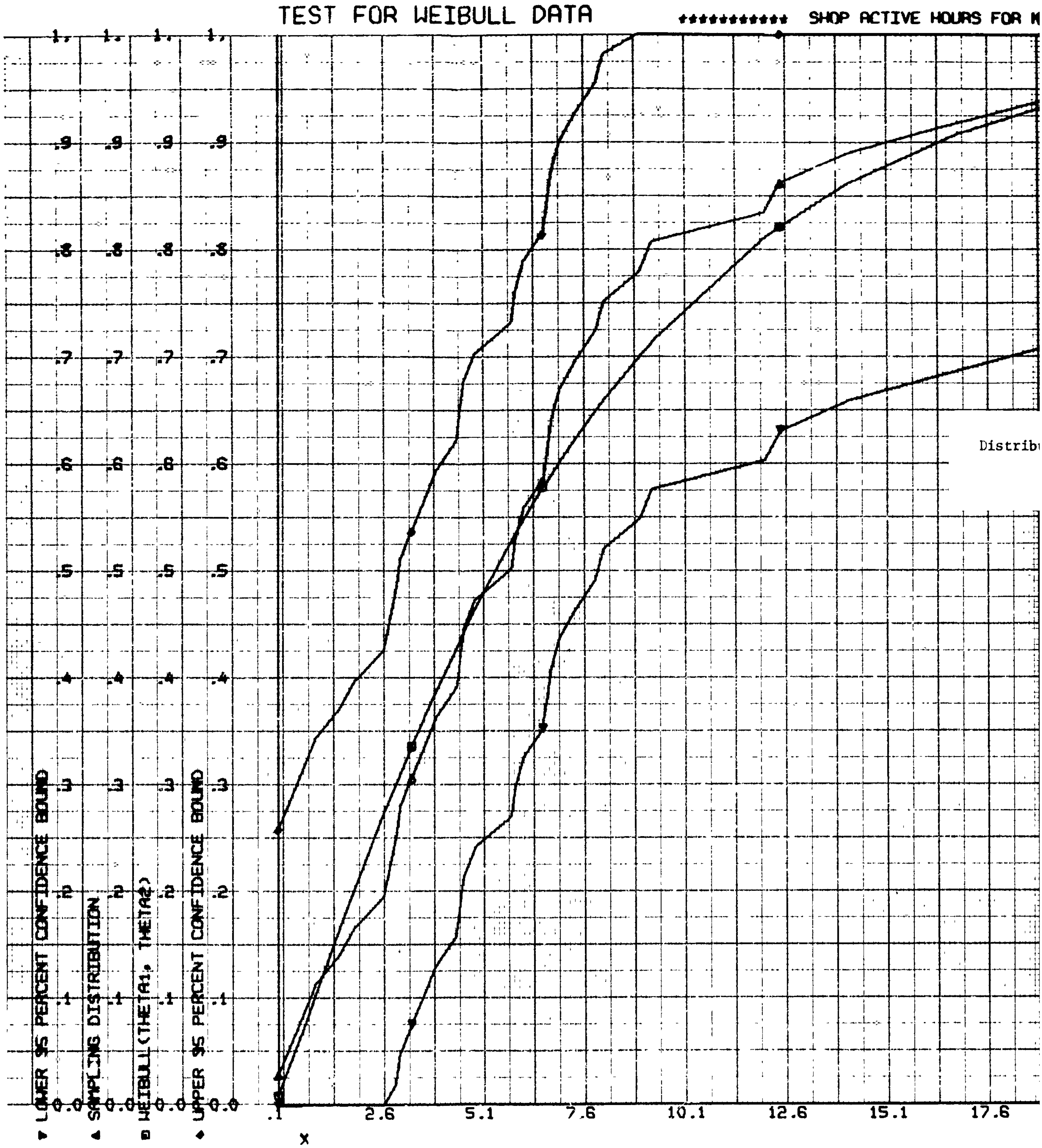


Figure 15
...n of Maintenance Events
Attack Radar
... Active H...



TEST FOR WEIBULL DATA
************ SHOP ACTIVE HOURS FOR M
Distrib
LOWER 95 PERCENT CONFIDENCE BOUND
SAMPLING DISTRIBUTION
WEIBULL(THETA1, THETA2)
UPPER 95 PERCENT CONFIDENCE BOUND
1.
.9
.8
.7
.6
.5
.4
.3
.2
.1
0.0
.1
2.6
5.1
7.6
10.1
12.6
15.1
17.6
X

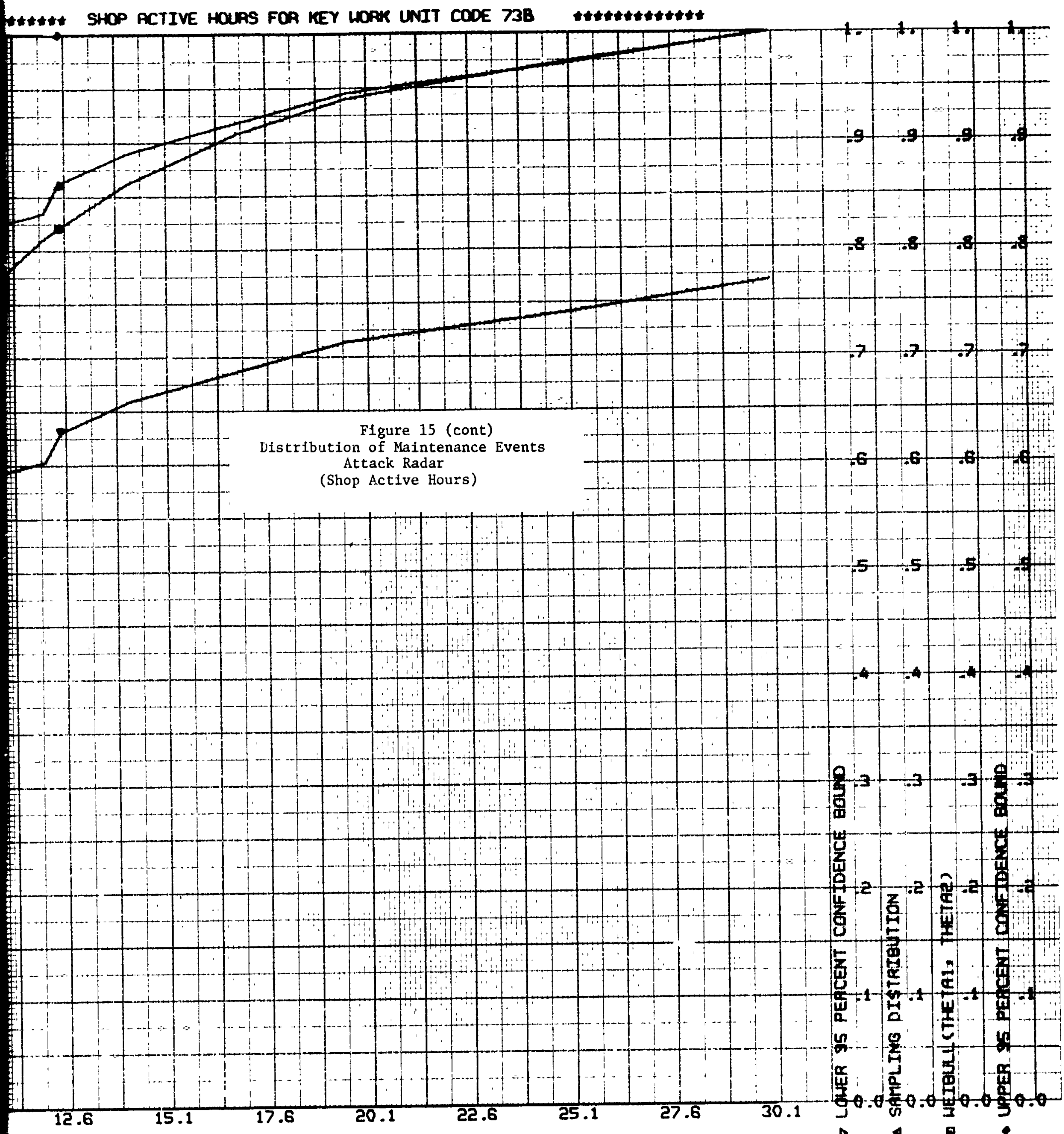


Figure 15 (cont)
Distribution of Maintenance Events
Attack Radar
(Shop Active Hours)

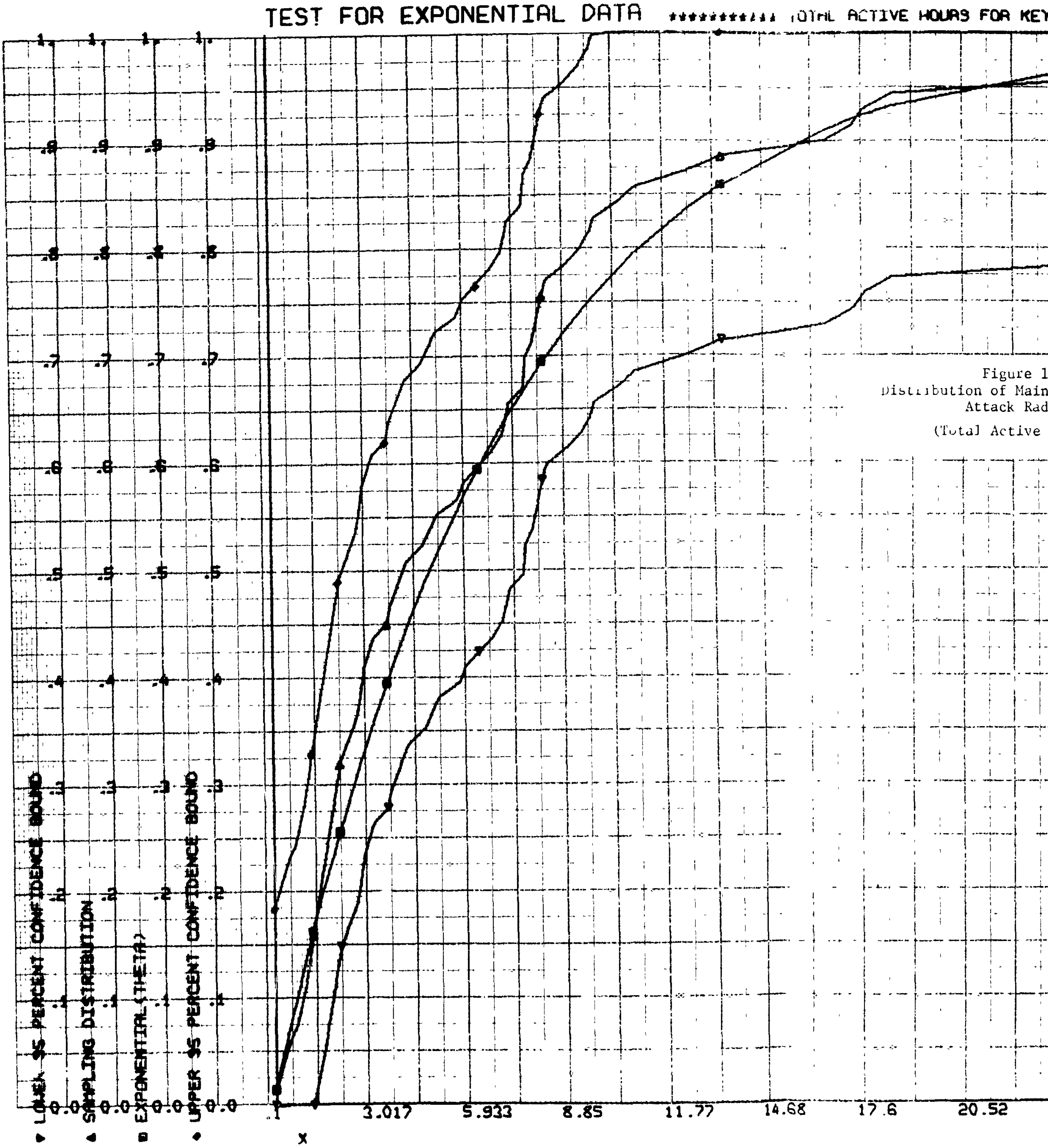


Figure 15
Distribution of Maint
Attack Rada

(Total Active H

9

*** TOTAL ACTIVE HOURS FOR KEY WORK UNIT CODE 73B **************

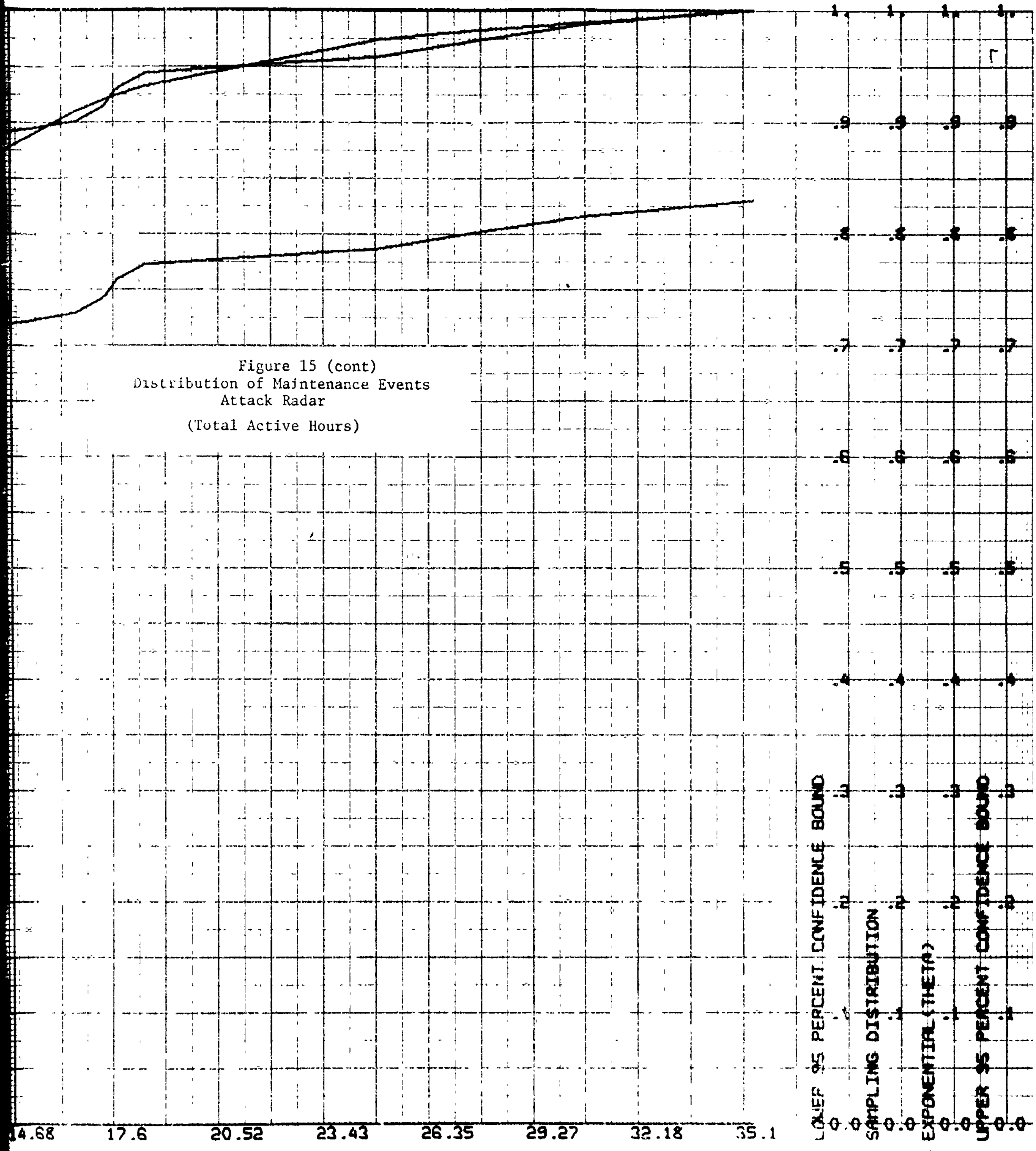


Figure 15 (cont)
Distribution of Maintenance Events
Attack Radar

(Total Active Hours)

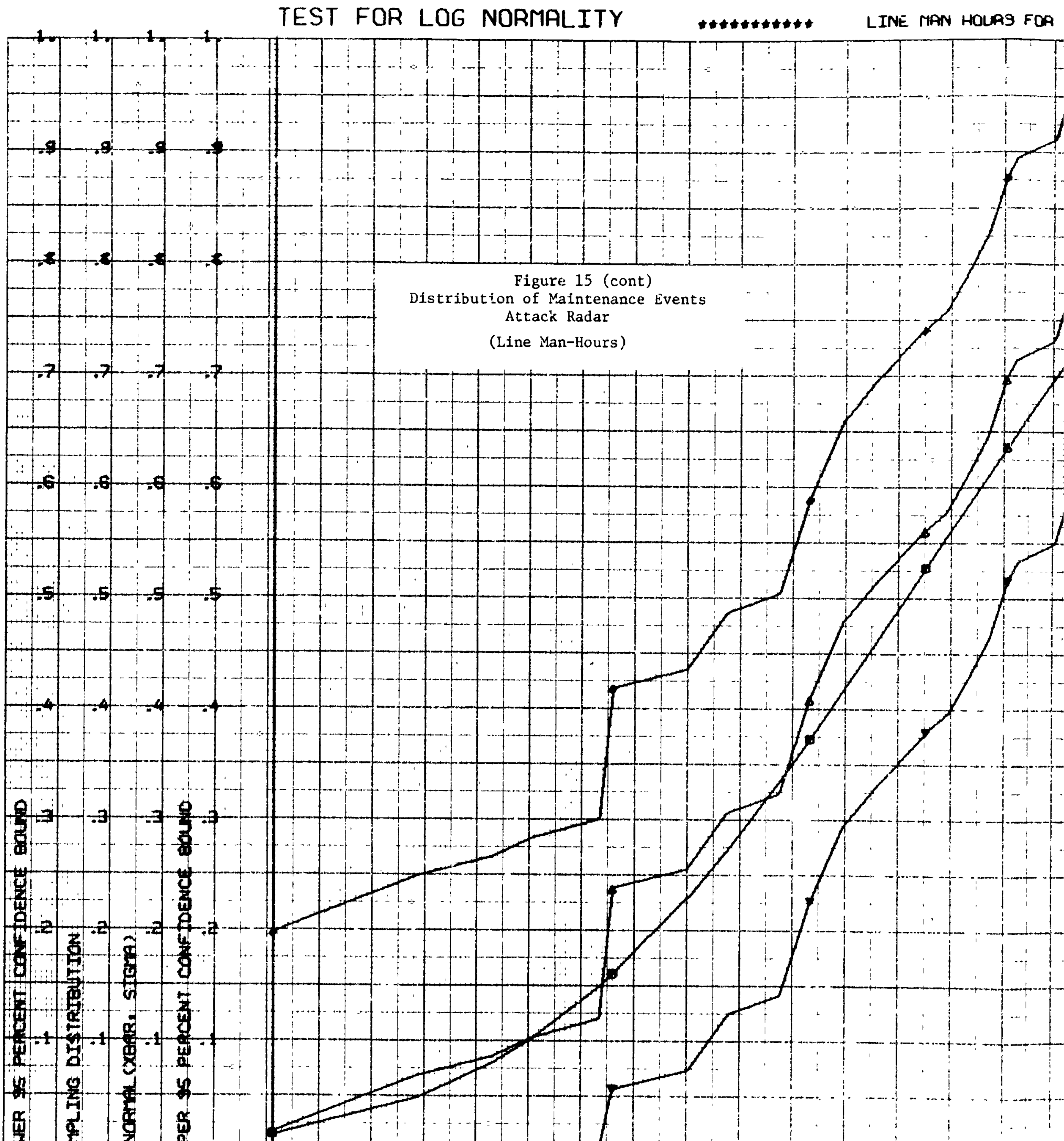
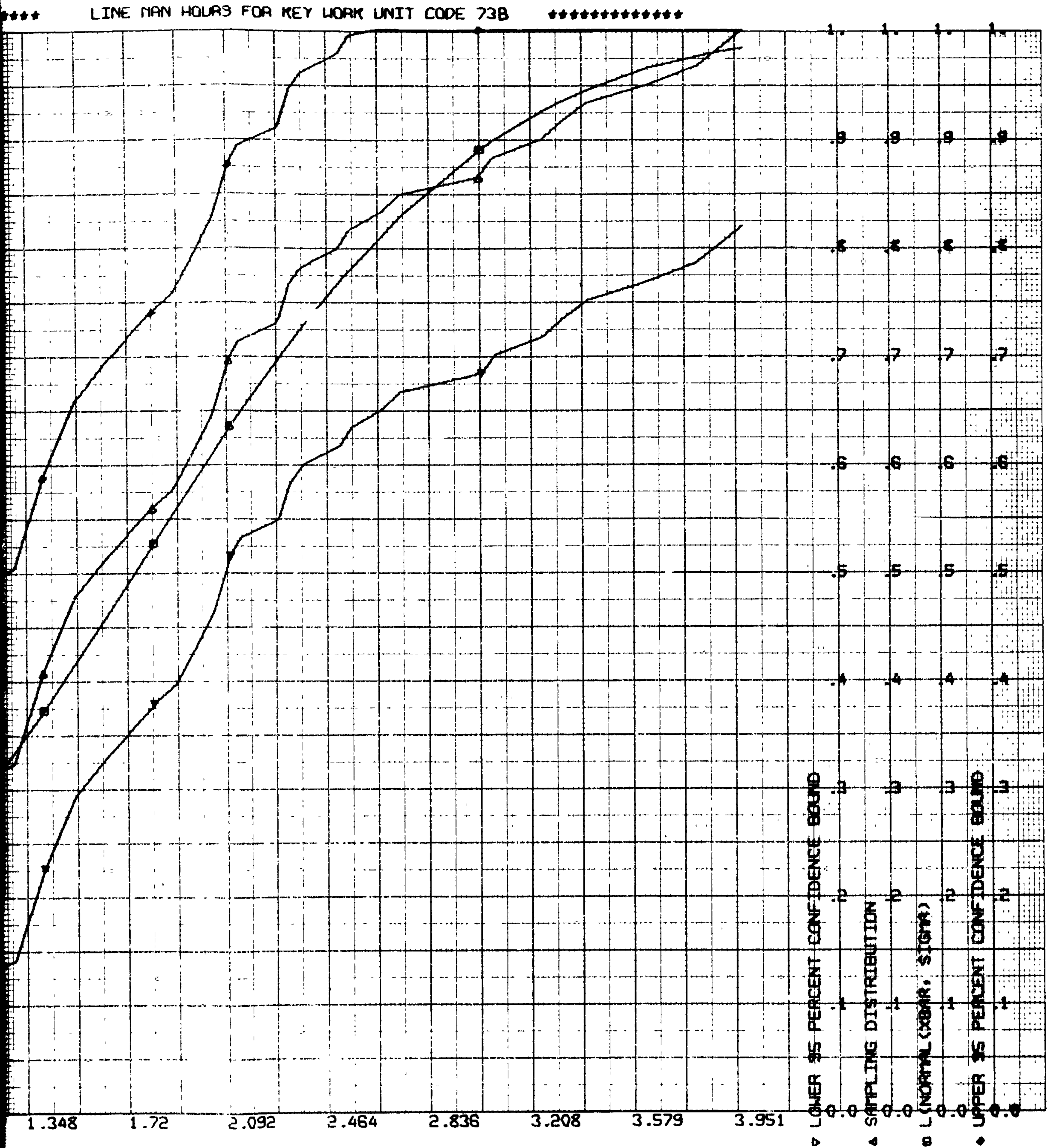


Figure 15 (cont)
Distribution of Maintenance Events
Attack Radar
(Line Man-Hours)



**** LINE MAN HOURS FOR KEY WORK UNIT CODE 73B **************
1.348
1.72
2.092
2.464
2.836
3.208
3.579
3.951
LOWER 95 PERCENT CONFIDENCE BOUND
SAMPLING DISTRIBUTION
L(NORMAL(XBAR, SIGMA)
UPPER 95 PERCENT CONFIDENCE BOUND

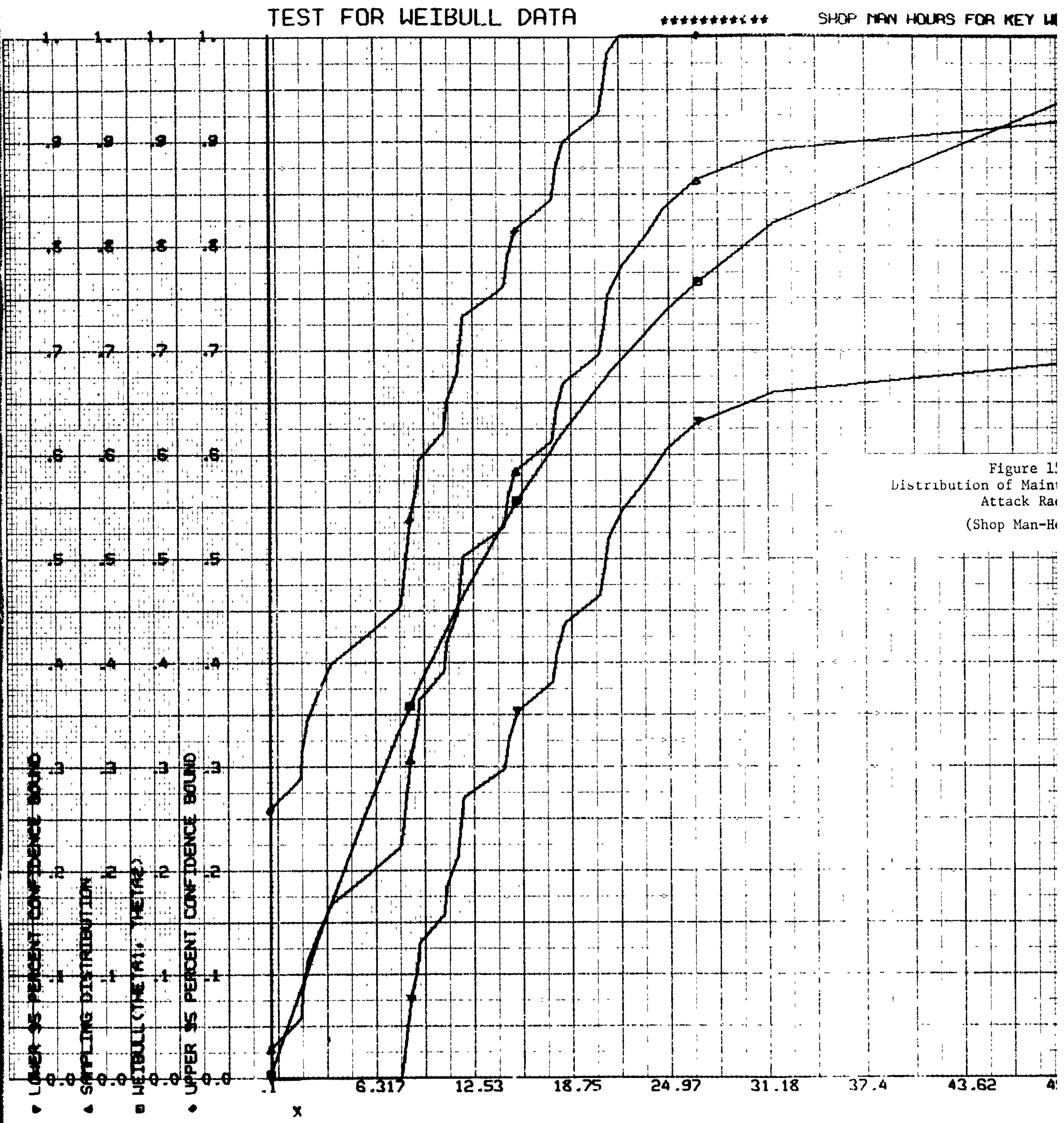


Figure 1
Distribution of Main
Attack Ra
(Shop Man-H

SHOP MAN HOURS FOR KEY WORK UNIT CODE 73B *************

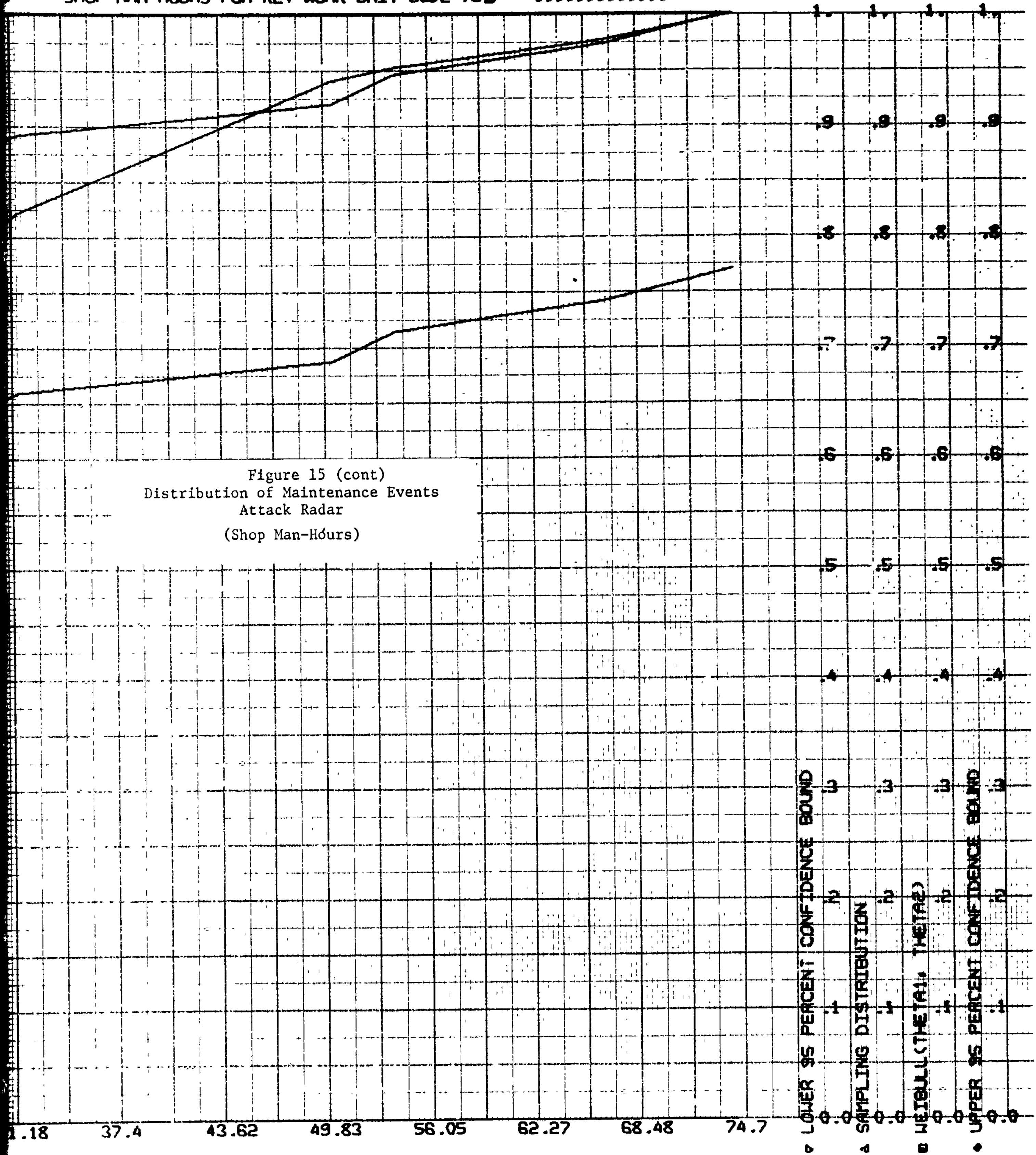


Figure 15 (cont)
Distribution of Maintenance Events
Attack Radar
(Shop Man-Hours)

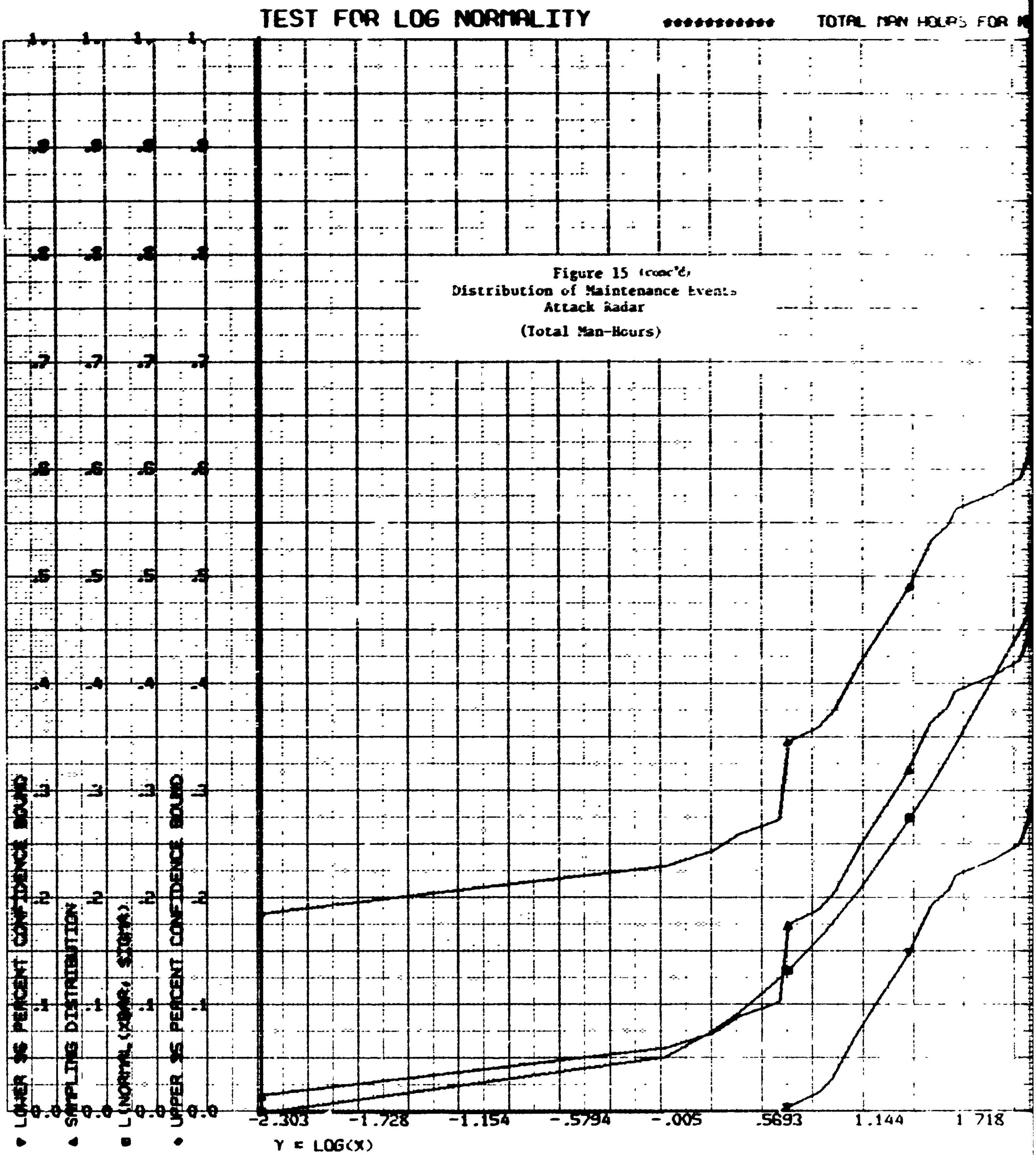
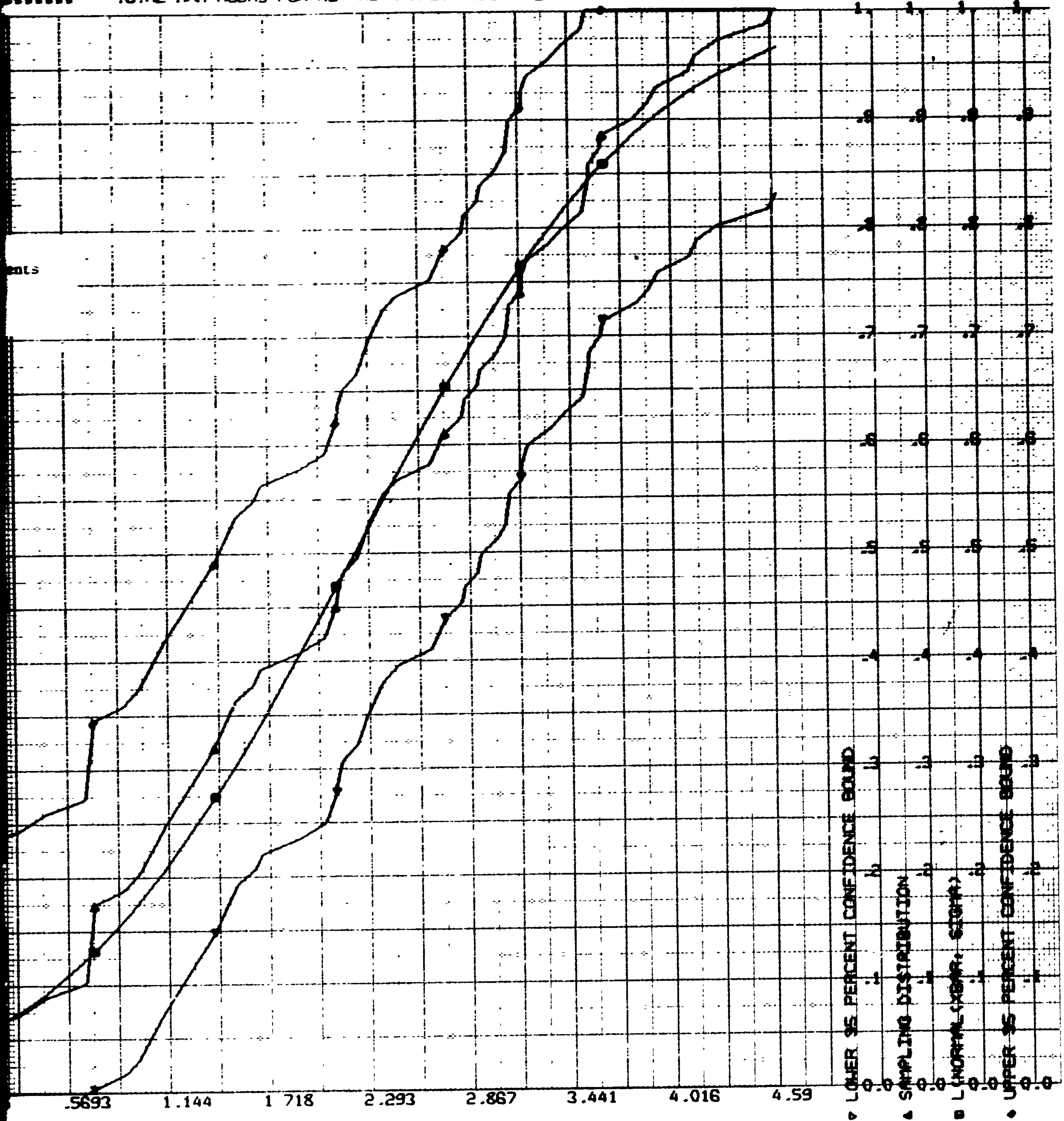


Figure 15 (conc'd)
Distribution of Maintenance Events
Attack Radar
(Total Man-Hours)

TOTAL MAN HOURS FOR KEY WORK UNIT CODE 73B



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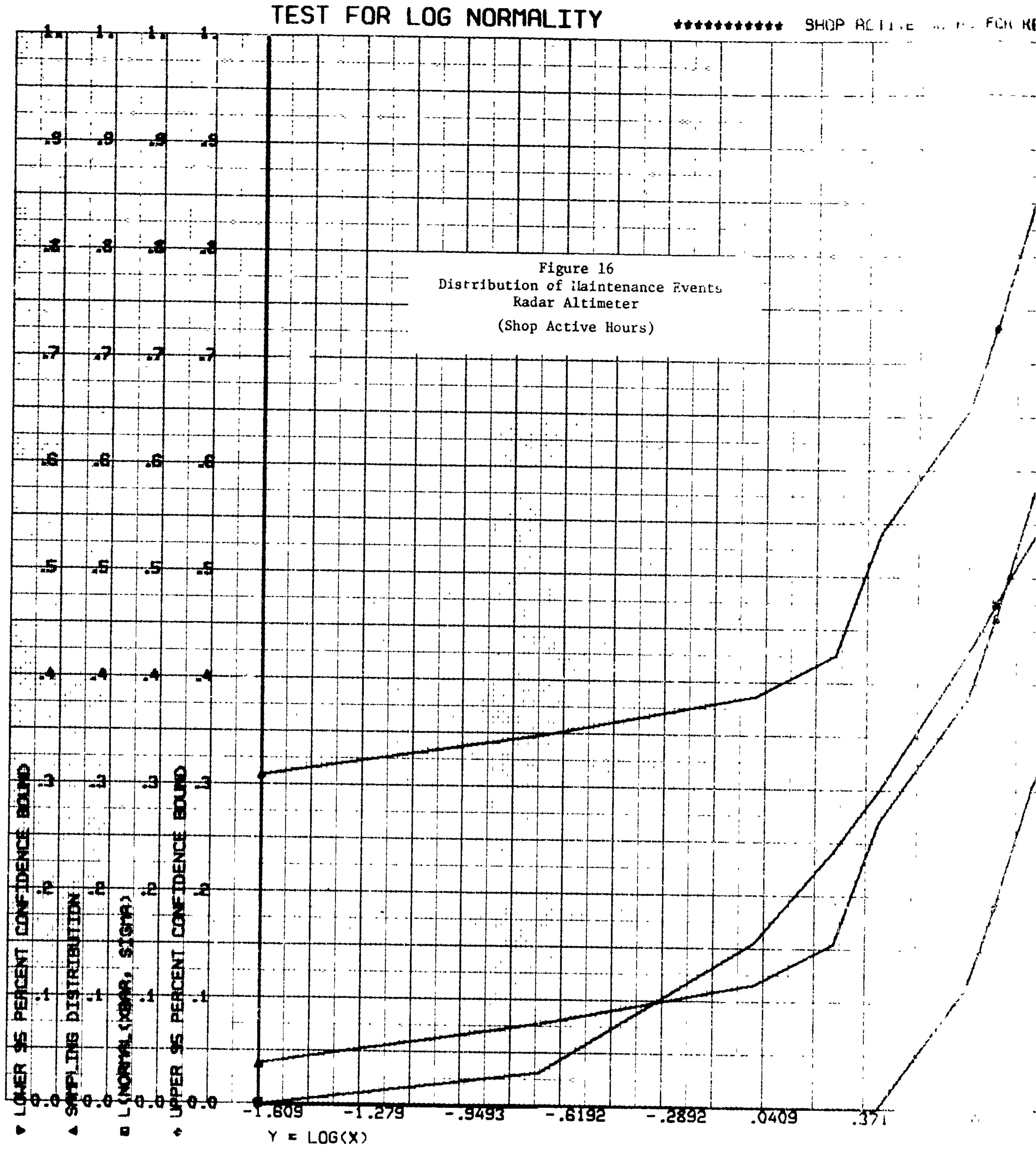
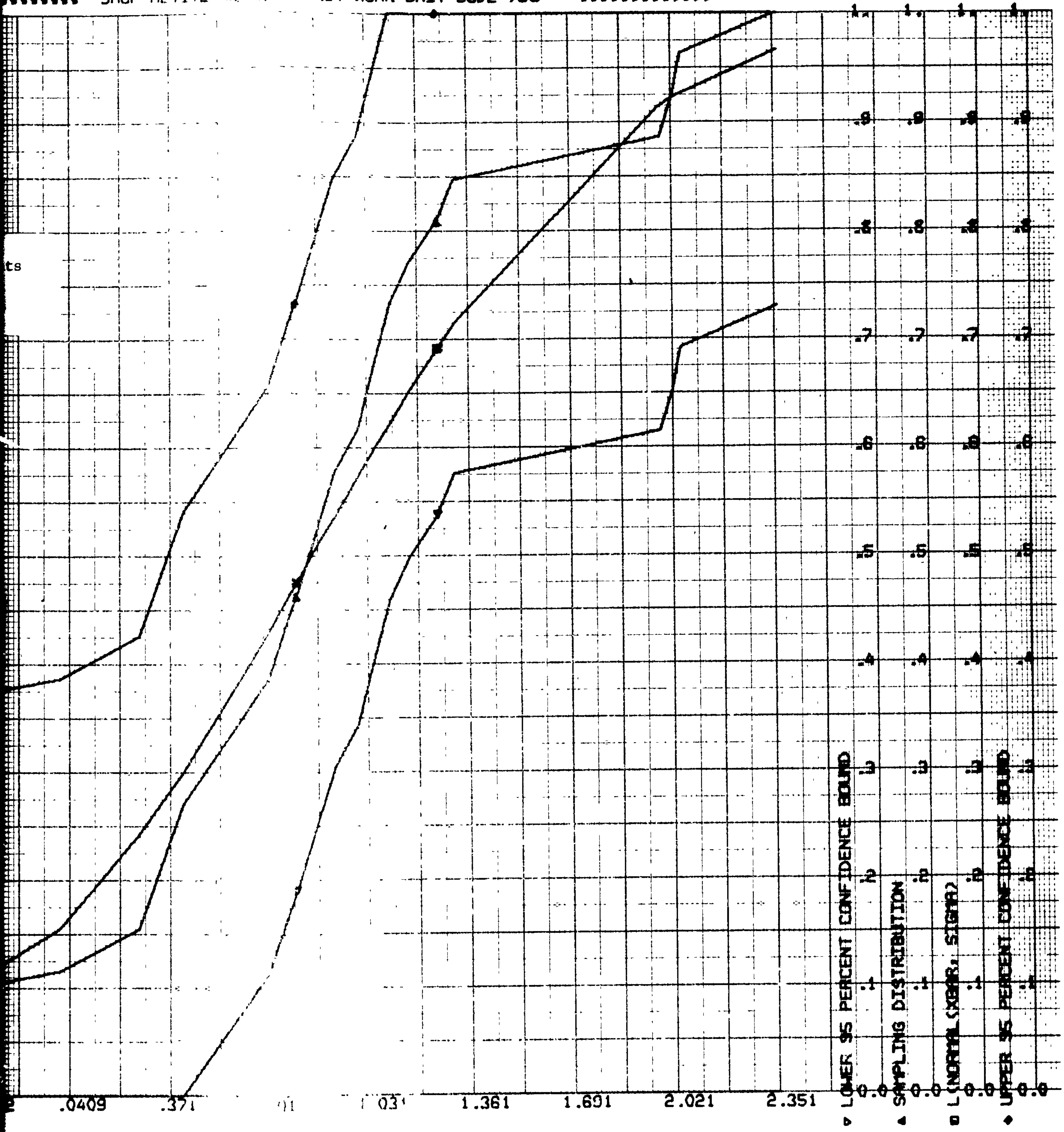
TEST FOR LOG NORMALITY



******** SHOP ACTIVE ... FOR KEY WORK UNIT CODE 73C **************



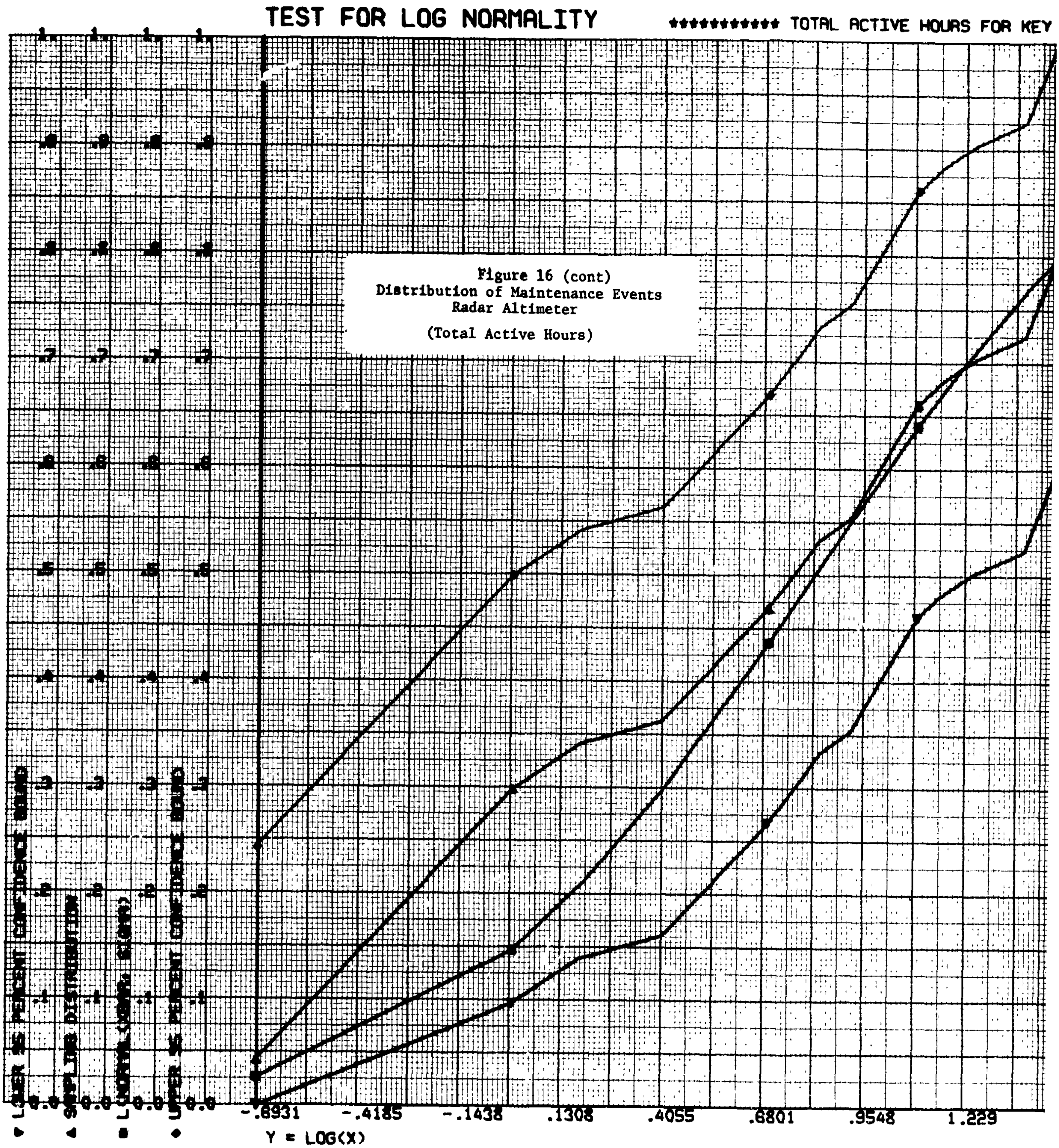
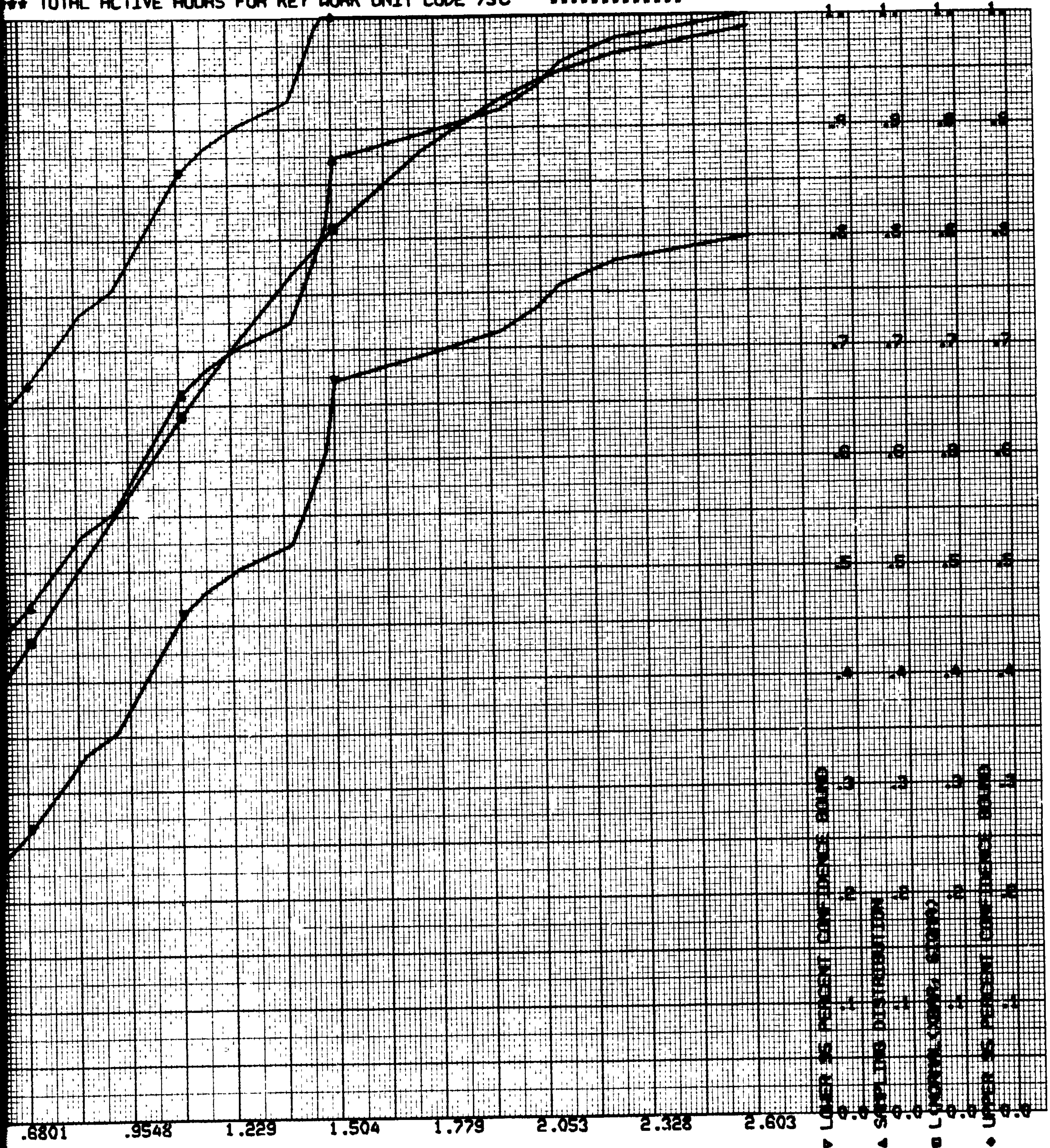
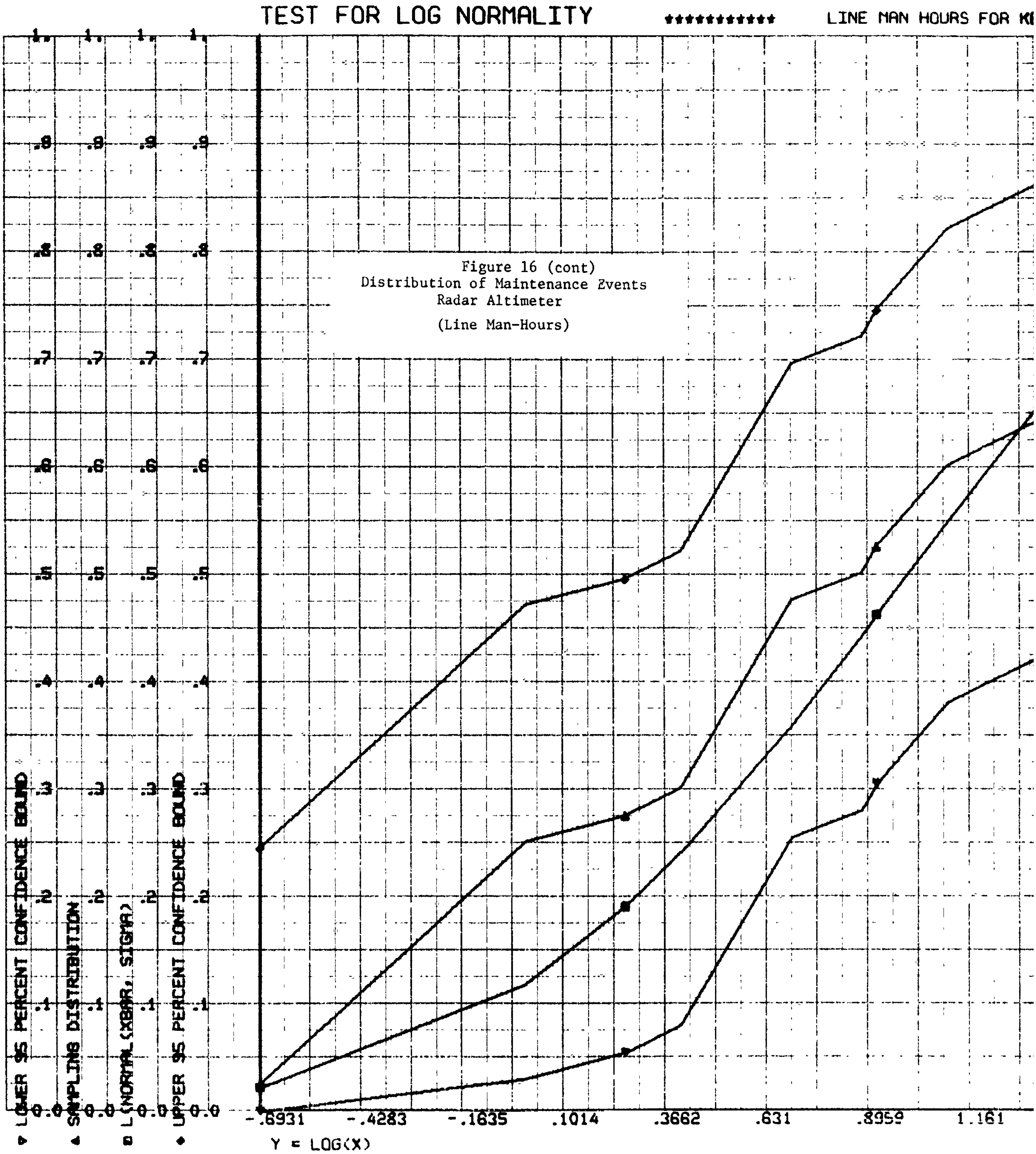


Figure 16 (cont)
Distribution of Maintenance Events
Radar Altimeter

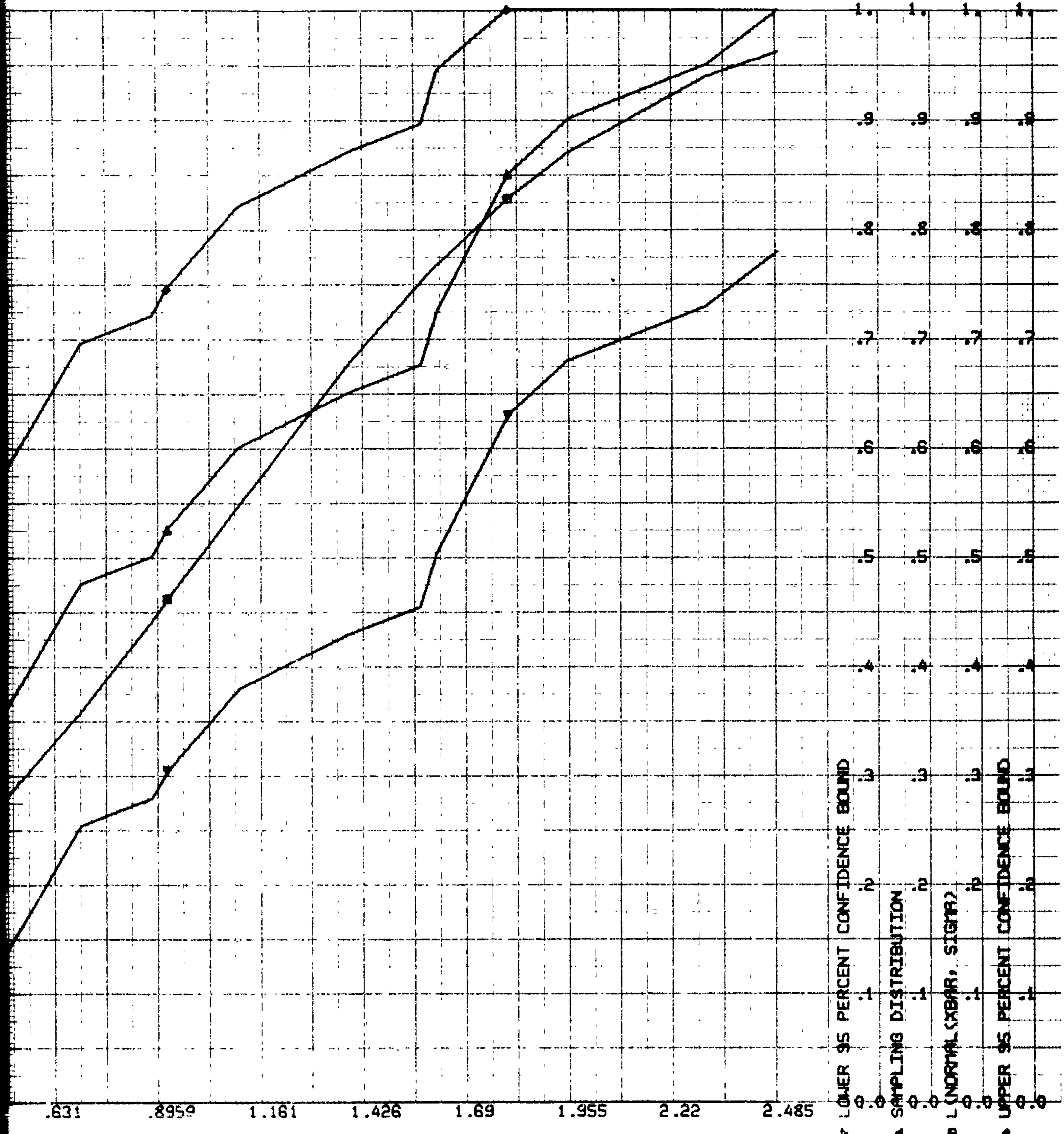
(Total Active Hours)

*** TOTAL ACTIVE HOURS FOR KEY WORK UNIT CODE 73C **************




TEST FOR LOG NORMALITY
****
LINE MAN HOURS FOR K
Figure 16 (cont)
Distribution of Maintenance Events
Radar Altimeter
(Line Man-Hours)
1. .9 .8 .7 .6 .5 .4 .3 .2 .1 0.0
-.6931 -.4283 -.1635 .1014 .3662 .631 .8959 1.161
Y = LOG(X)
LOWER 95 PERCENT CONFIDENCE BOUND
SAMPLING DISTRIBUTION
L(NORMAL(XBAR, SIGMA)
UPPER 95 PERCENT CONFIDENCE BOUND

****** LINE MAN HOURS FOR KEY WORK UNIT CODE 73C **************



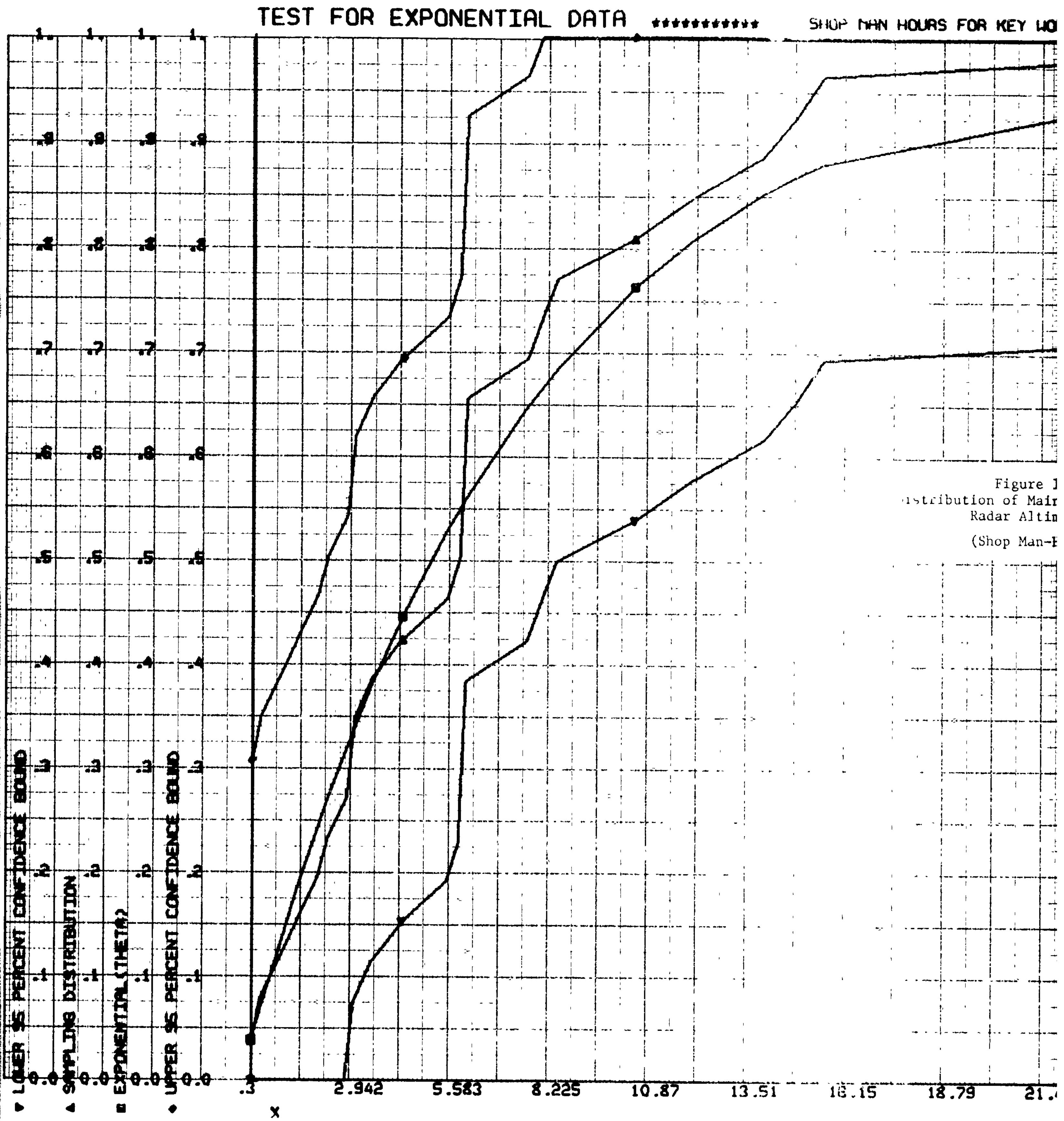


Figure 1
Distribution of Main
Radar Altim

(Shop Man-H

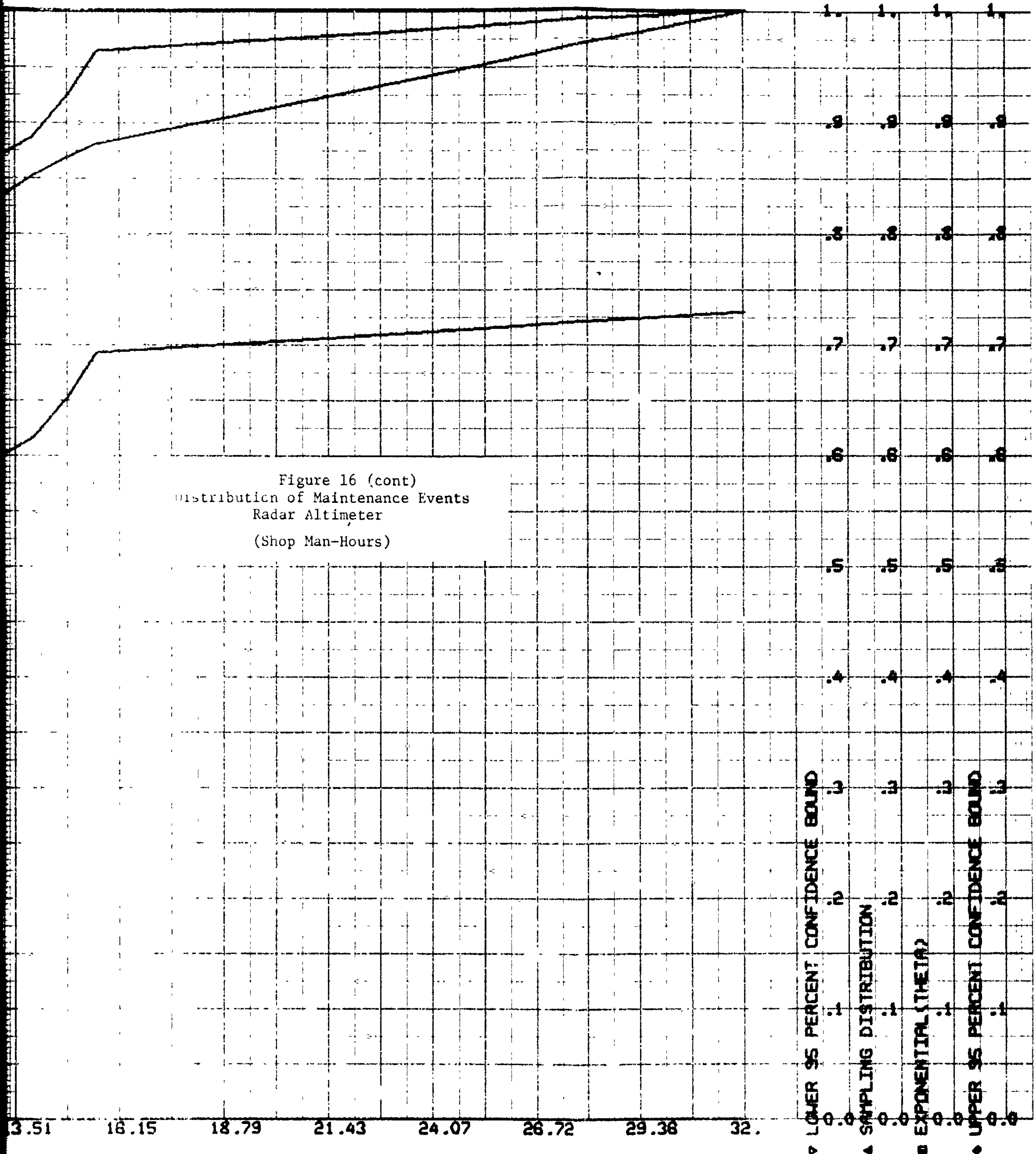
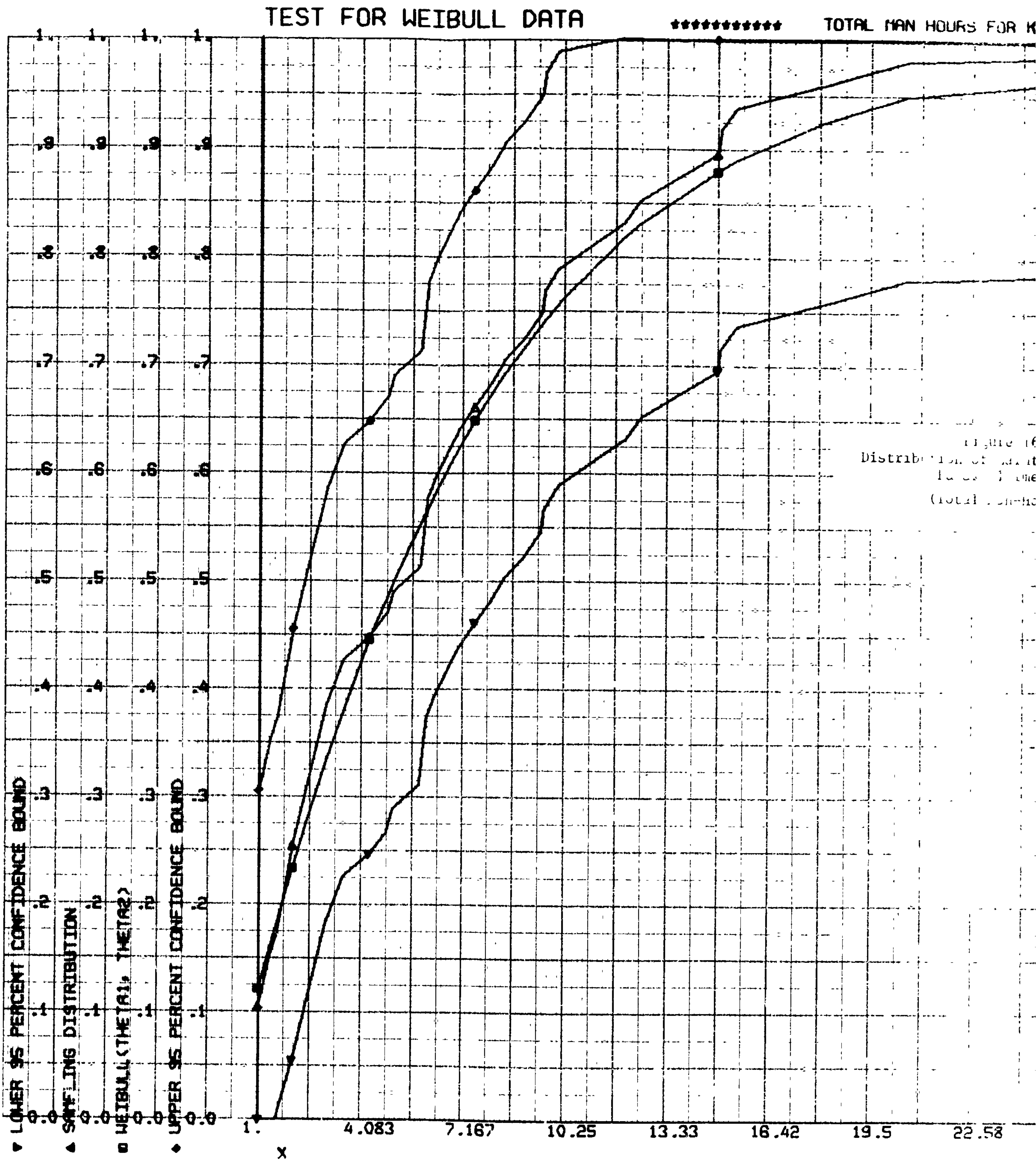
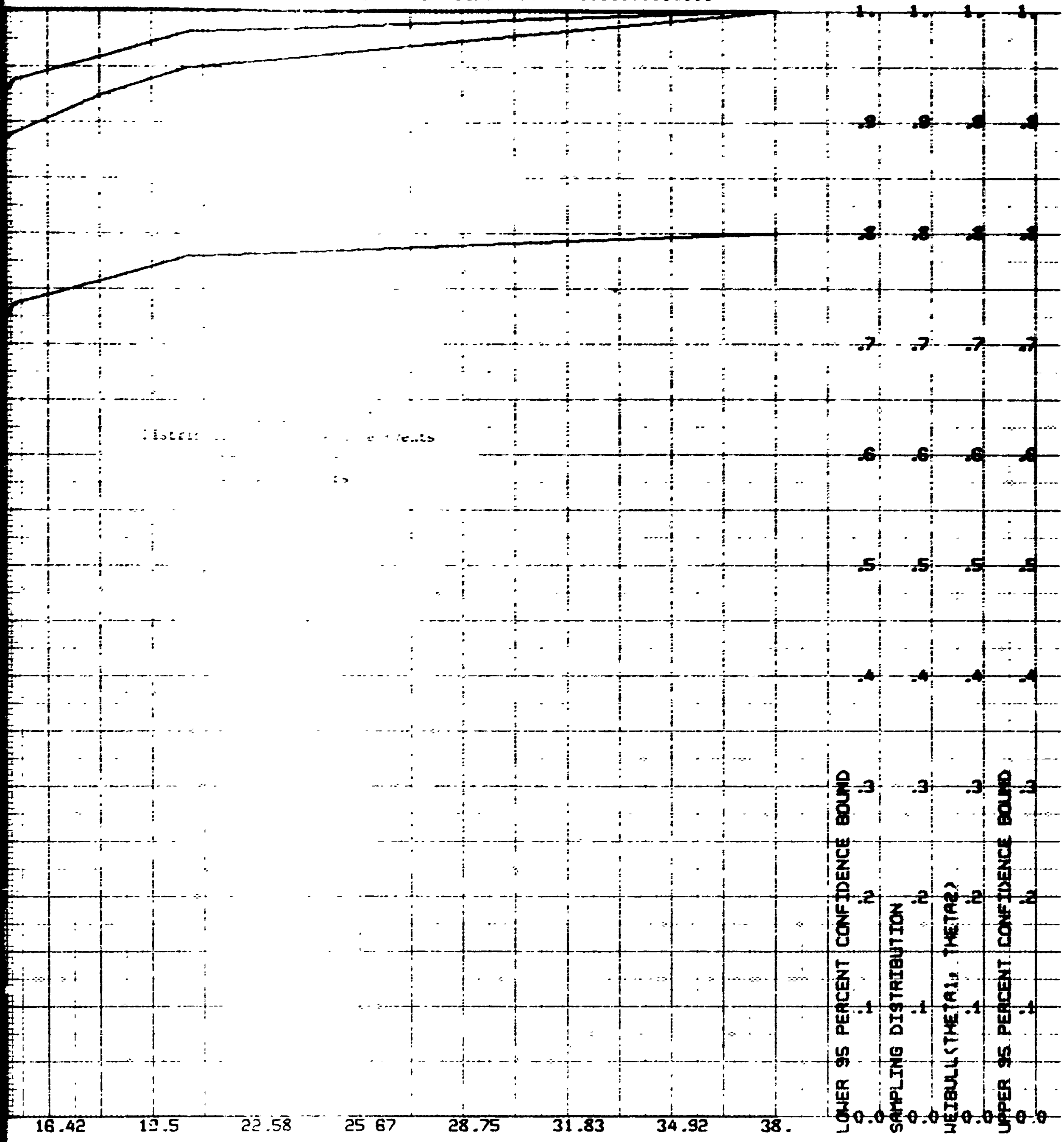


Figure 16 (cont)
Distribution of Maintenance Events
Radar Altimeter
(Shop Man-Hours)



TEST FOR WEIBULL DATA
****
TOTAL MAN HOURS FOR K
LOWER 95 PERCENT CONFIDENCE BOUND
SAMPLING DISTRIBUTION
WEIBULL(THETA1, THETA2)
UPPER 95 PERCENT CONFIDENCE BOUND
0.0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.
1.
4.083
7.167
10.25
13.33
16.42
19.5
22.58
X
Distrib

****** TOTAL MAN HOURS FOR KEY WORK UNIT CODE 73C **************



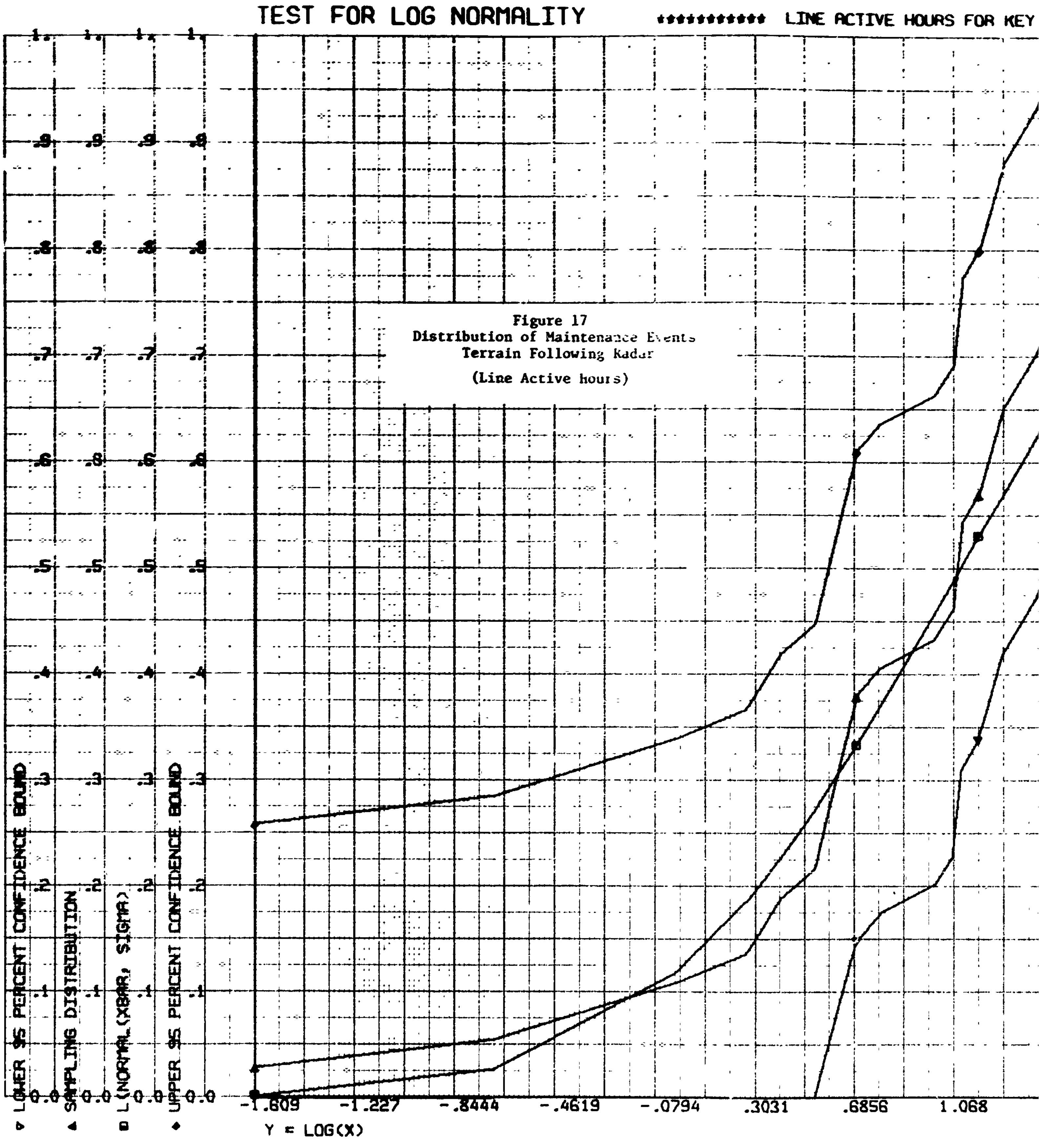
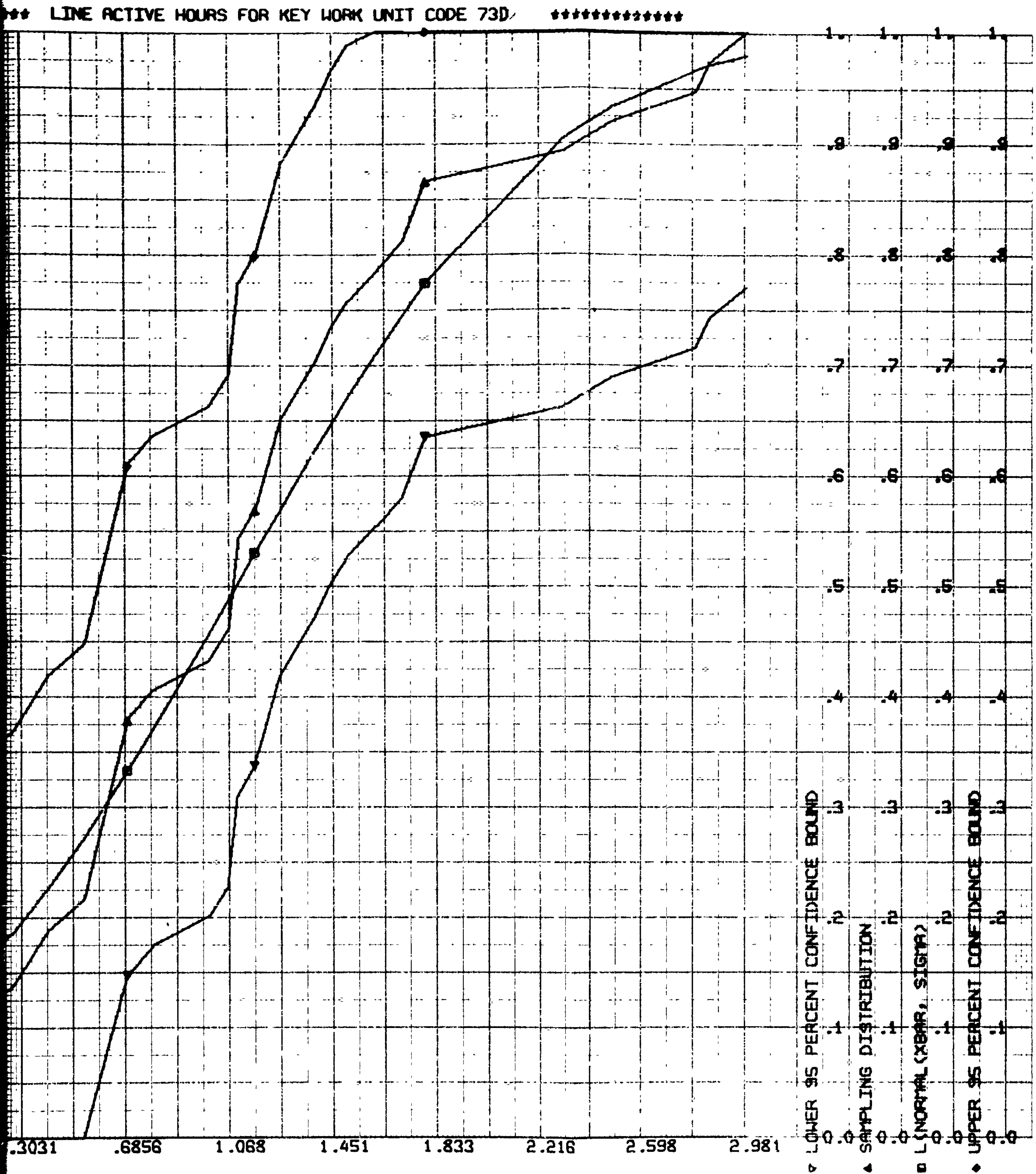
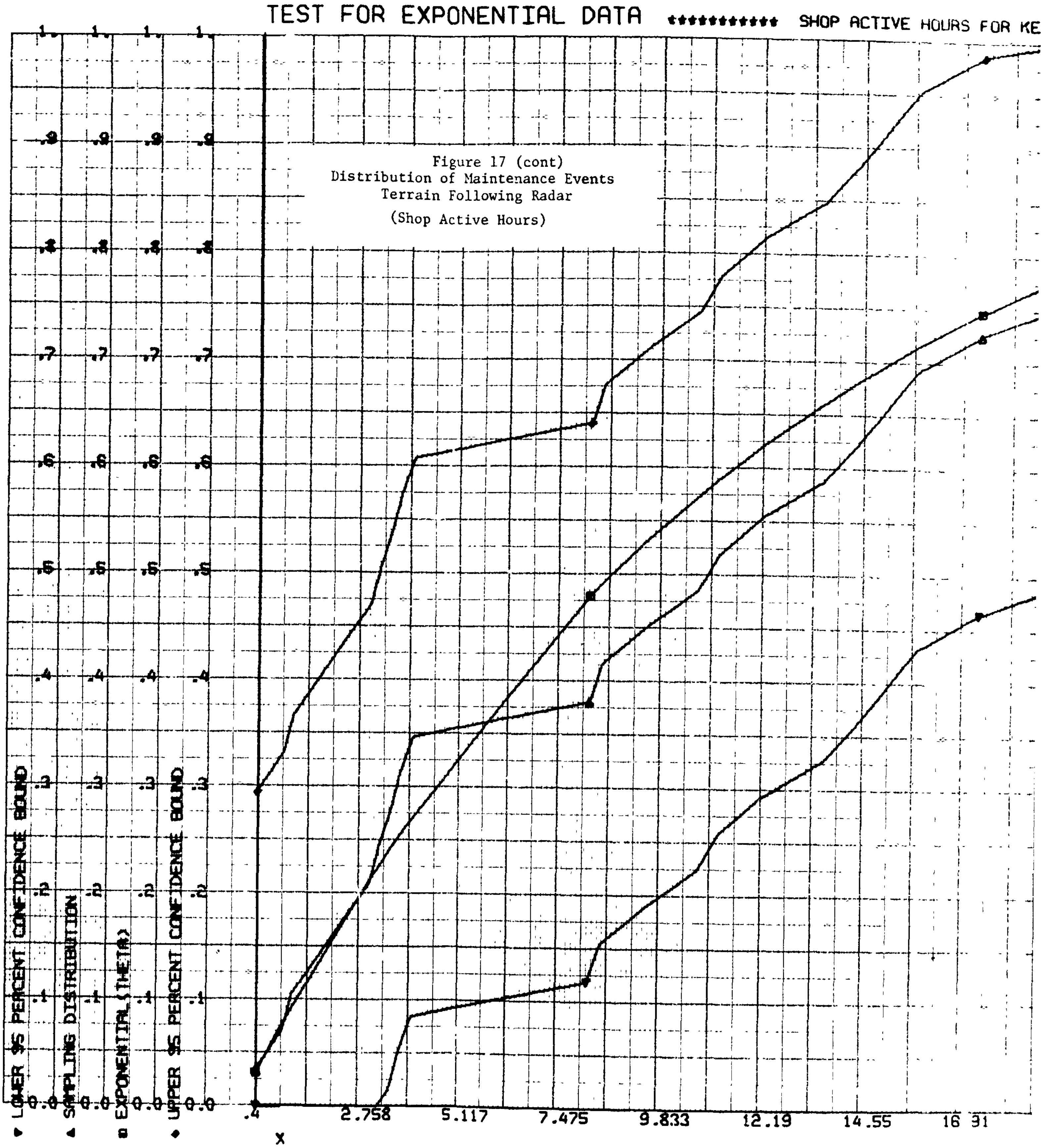


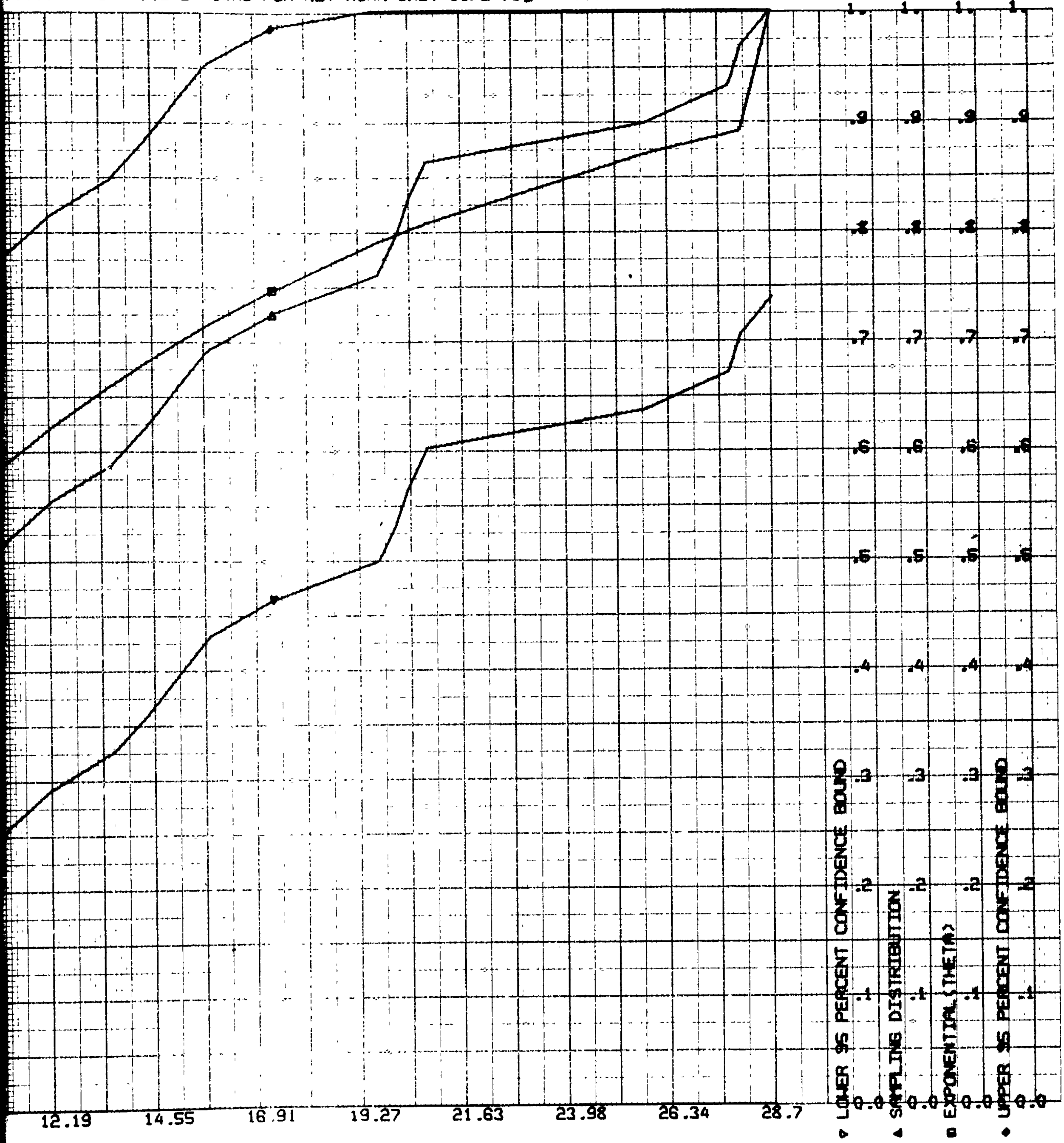
Figure 17
Distribution of Maintenance Events
Terrain Following Radar
(Line Active hours)



*** LINE ACTIVE HOURS FOR KEY WORK UNIT CODE 73D *************
.3031
.6856
1.068
1.451
1.833
2.216
2.598
2.981
LOWER 95 PERCENT CONFIDENCE BOUND
SAMPLING DISTRIBUTION
L(NORMAL(XBAR, SIGMA)
UPPER 95 PERCENT CONFIDENCE BOUND
1.
.9
.8
.7
.6
.5
.4
.3
.2
.1
0.0


TEST FOR EXPONENTIAL DATA ************ SHOP ACTIVE HOURS FOR KE
Figure 17 (cont)
Distribution of Maintenance Events
Terrain Following Radar
(Shop Active Hours)
LOWER 95 PERCENT CONFIDENCE BOUND
SAMPLING DISTRIBUTION
EXPONENTIAL (THETA)
UPPER 95 PERCENT CONFIDENCE BOUND
.4
2.758
5.117
7.475
9.833
12.19
14.55
16.91
X

***** SHOP ACTIVE HOURS FOR KEY WORK UNIT CODE 73D **************



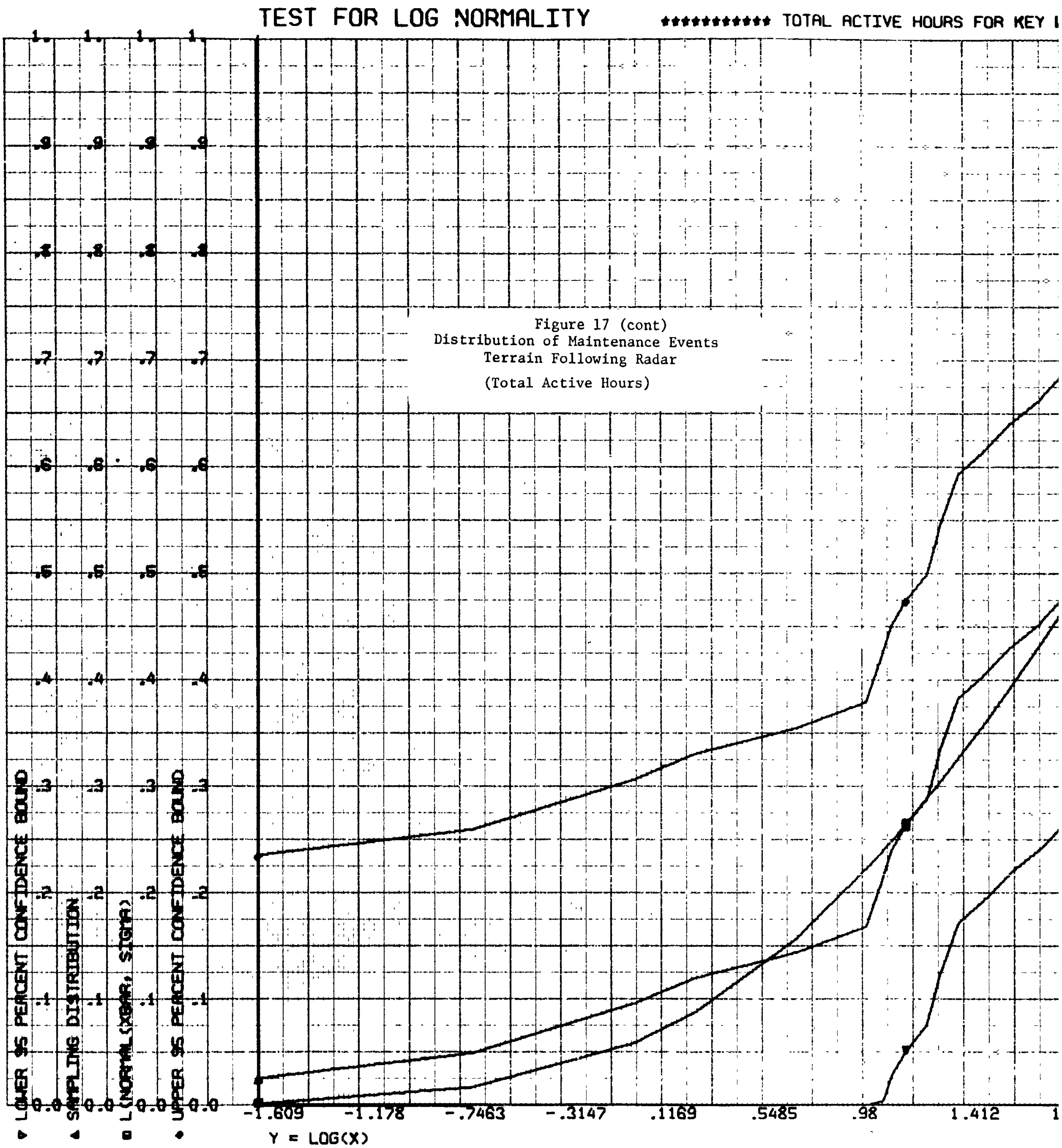
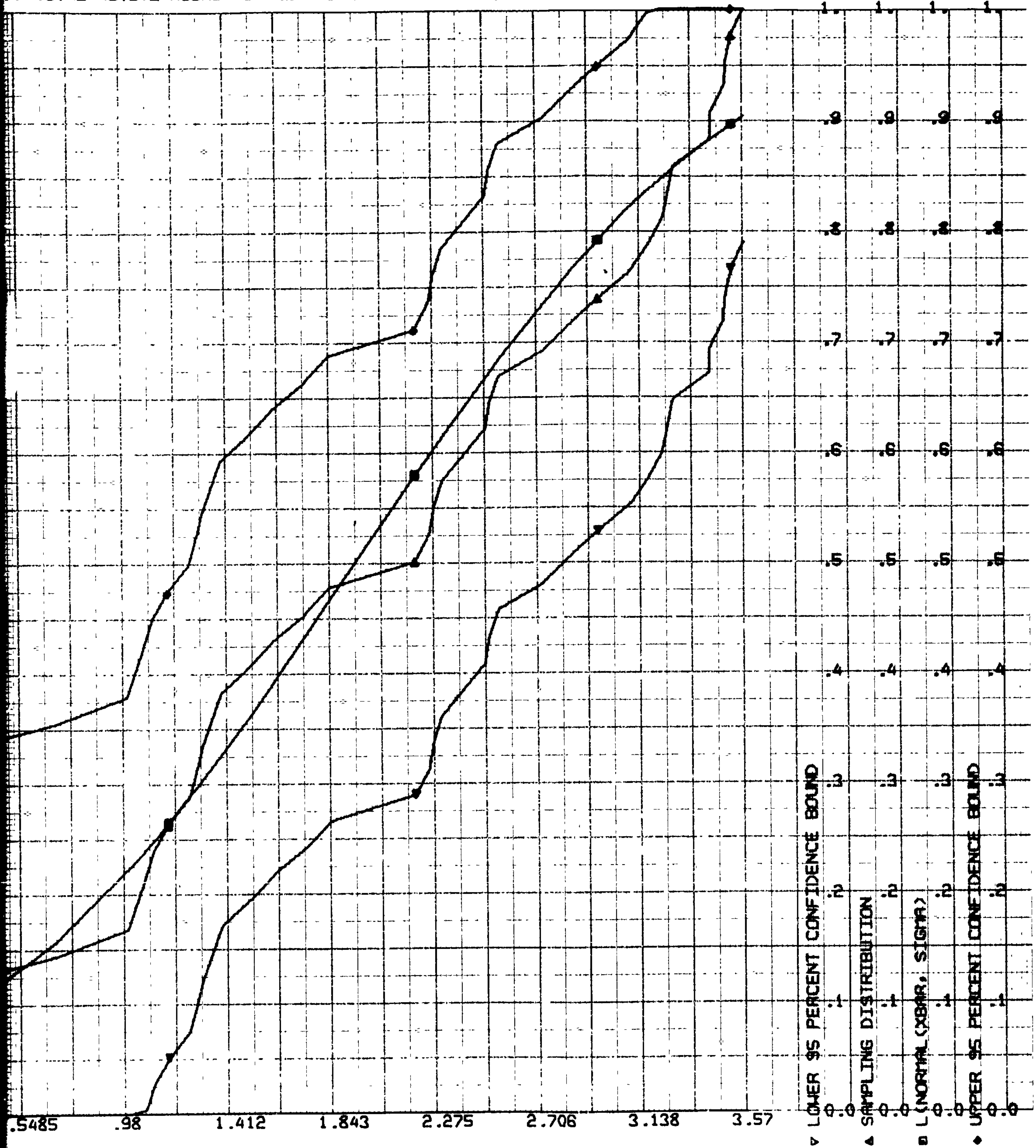


Figure 17 (cont)
Distribution of Maintenance Events
Terrain Following Radar
(Total Active Hours)

** TOTAL ACTIVE HOURS FOR KEY WORK UNIT CODE 73D **************



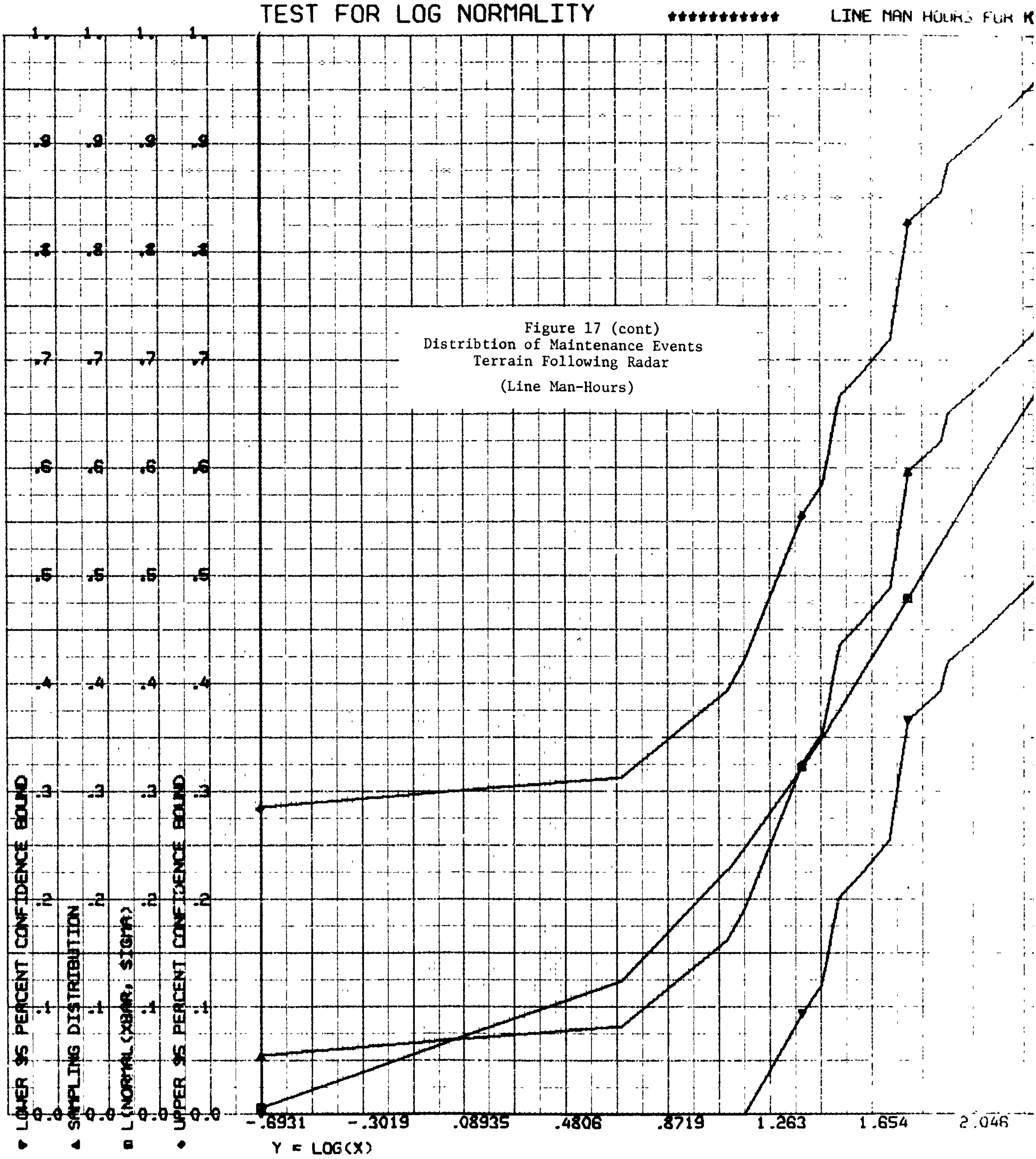
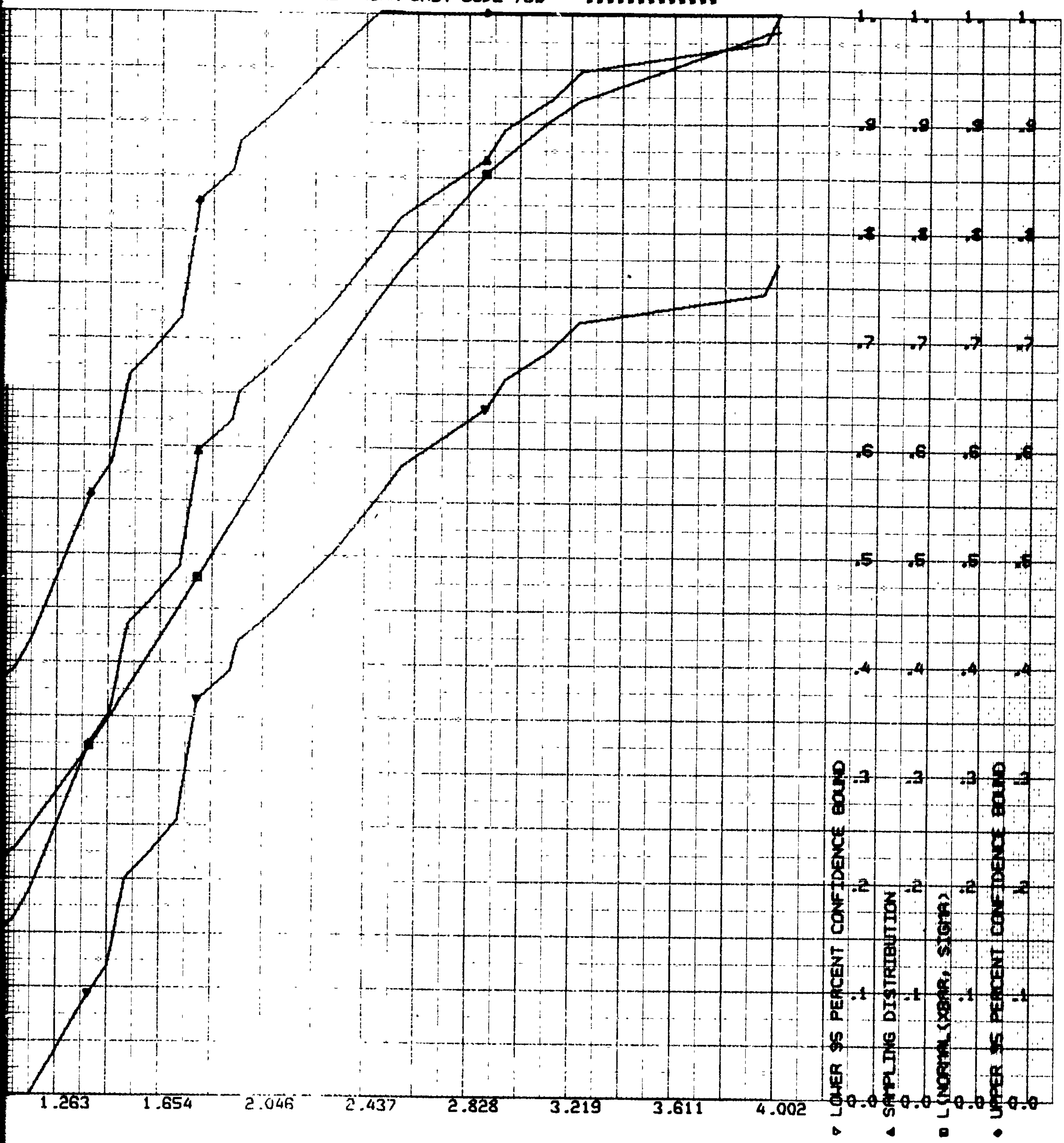


Figure 17 (cont)
Distribtion of Maintenance Events
Terrain Following Radar
(Line Man-Hours)

LINE MAN HOURS FOR KEY WORK UNIT CODE 73D



TEST FOR WEIBULL DATA ************ SHOP MAN HOURS FOR KEY I

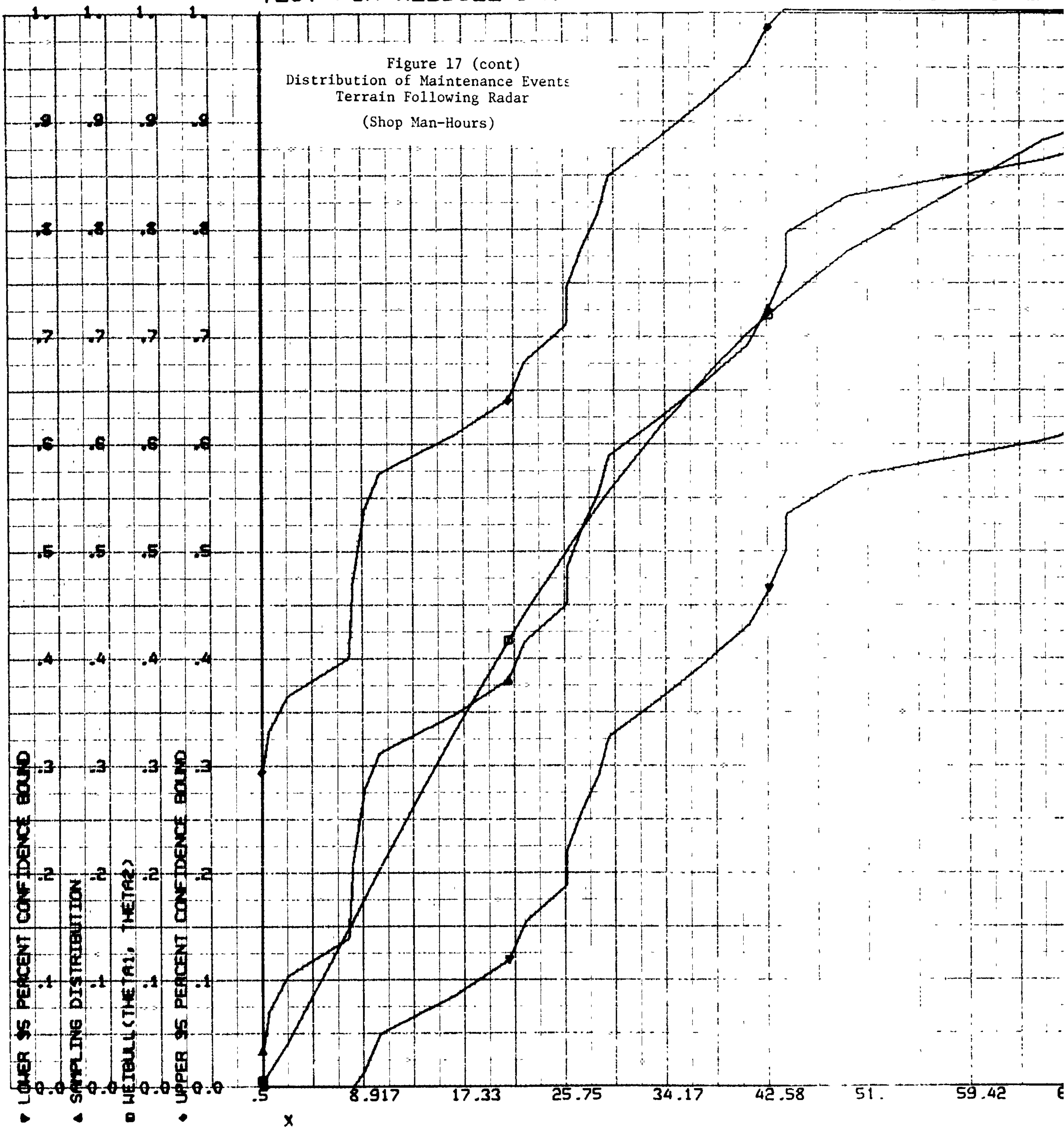
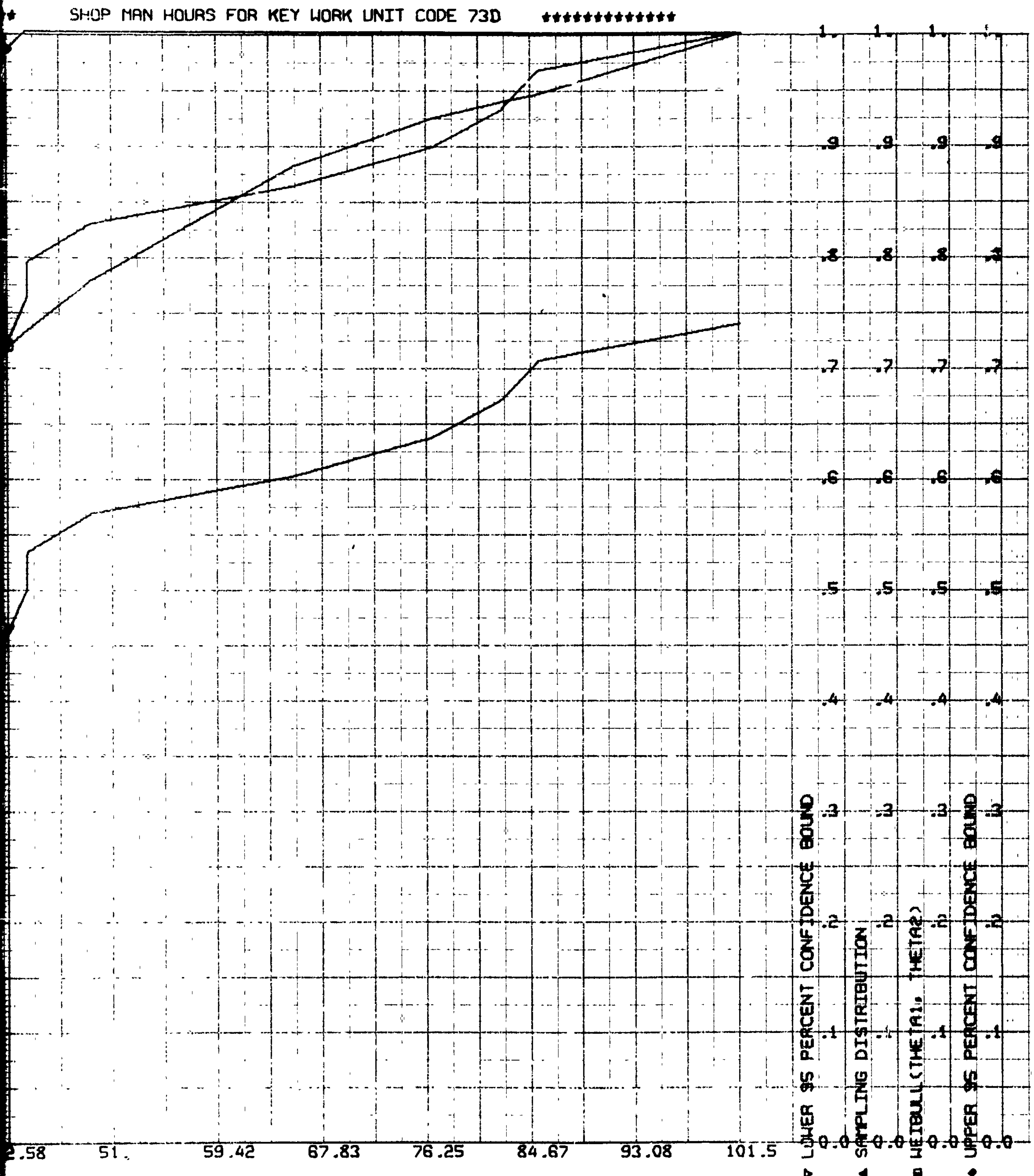


Figure 17 (cont)
Distribution of Maintenance Events
Terrain Following Radar
(Shop Man-Hours)

1



SHOP MAN HOURS FOR KEY WORK UNIT CODE 73D **************
2.58
51.
59.42
67.83
76.25
84.67
93.08
101.5
LOWER 95 PERCENT CONFIDENCE BOUND
SAMPLING DISTRIBUTION
WEIBULL(THETA1, THETA2)
UPPER 95 PERCENT CONFIDENCE BOUND
1.
.9
.8
.7
.6
.5
.4
.3
.2
.1
0.0

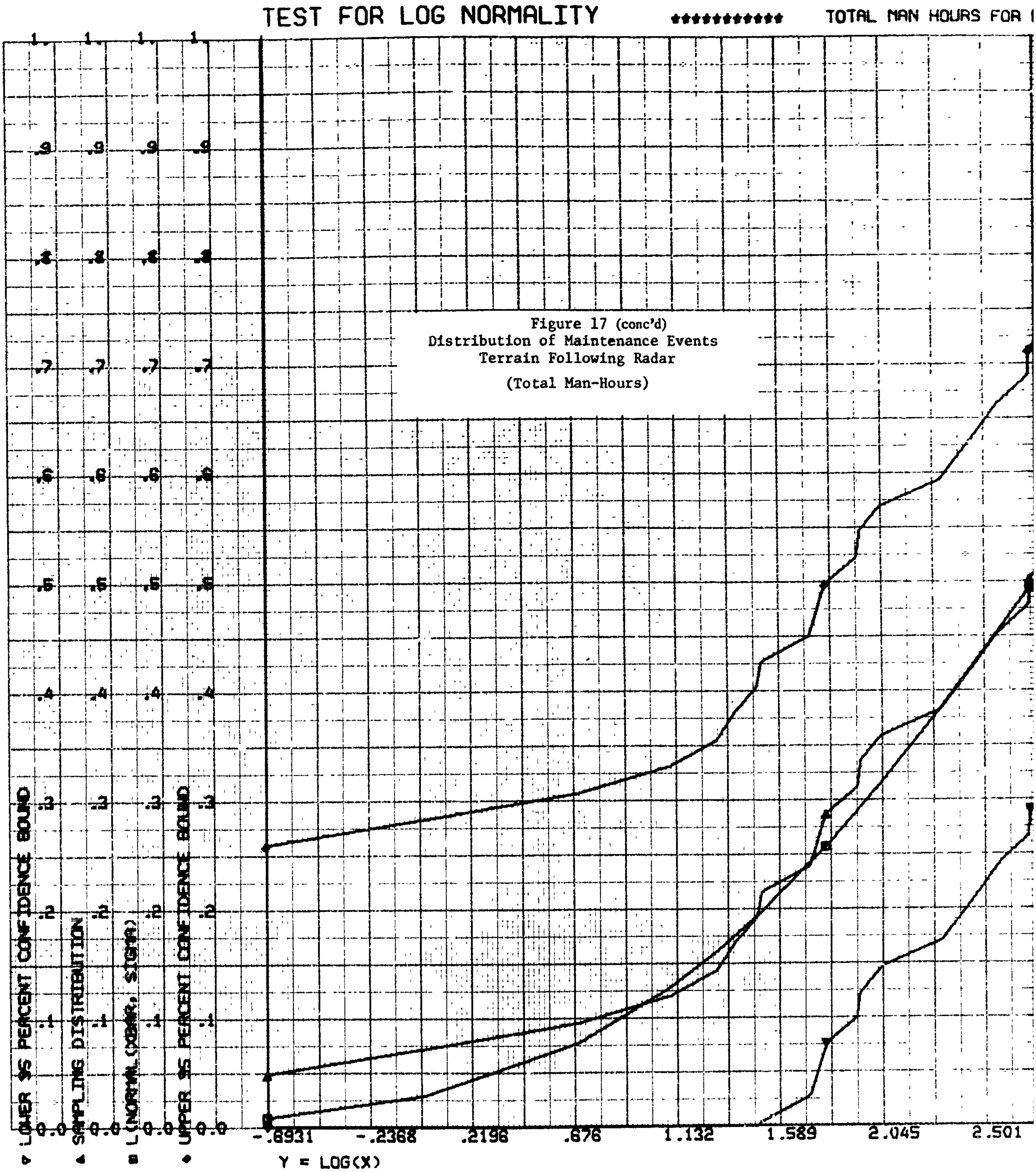
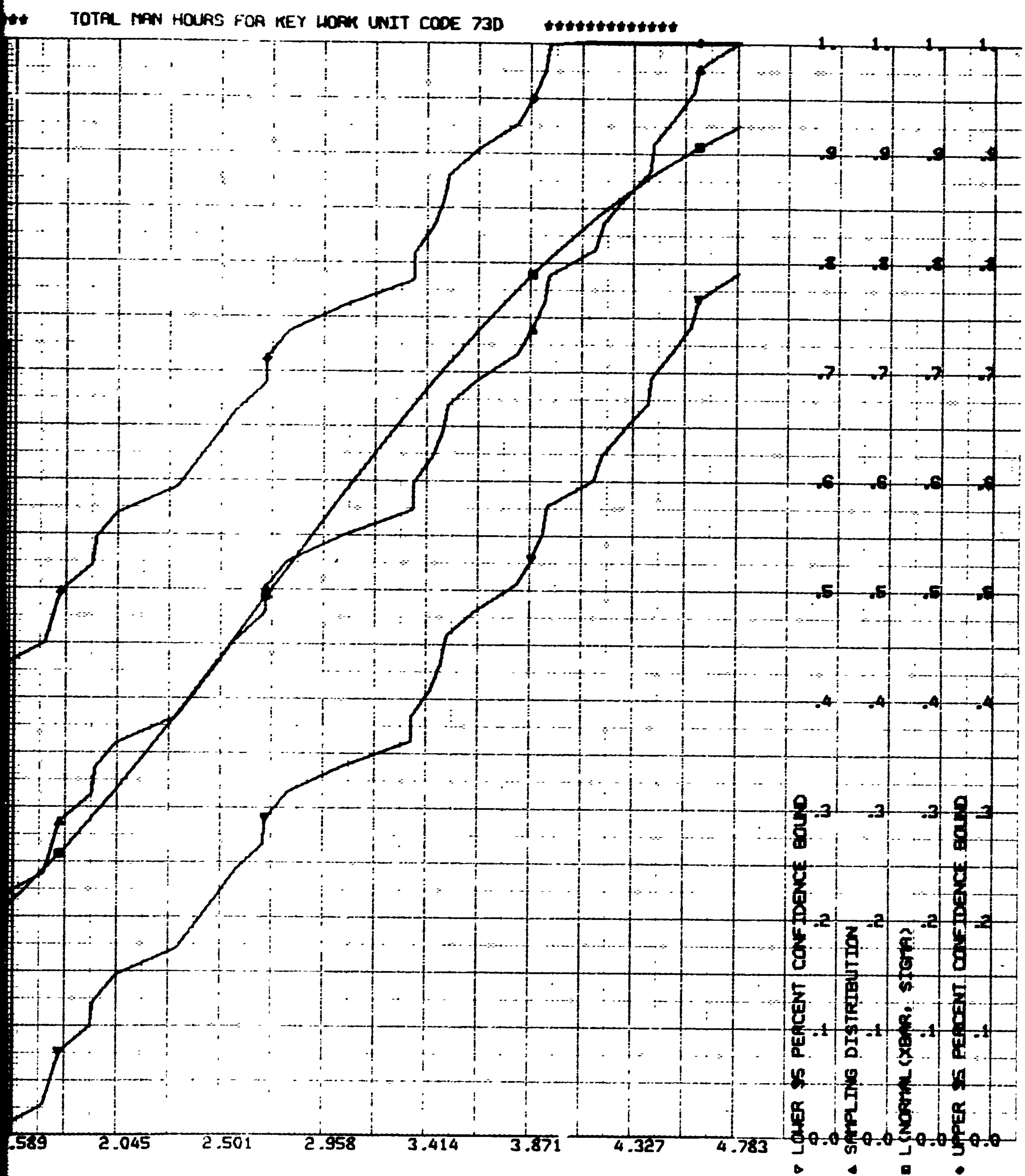
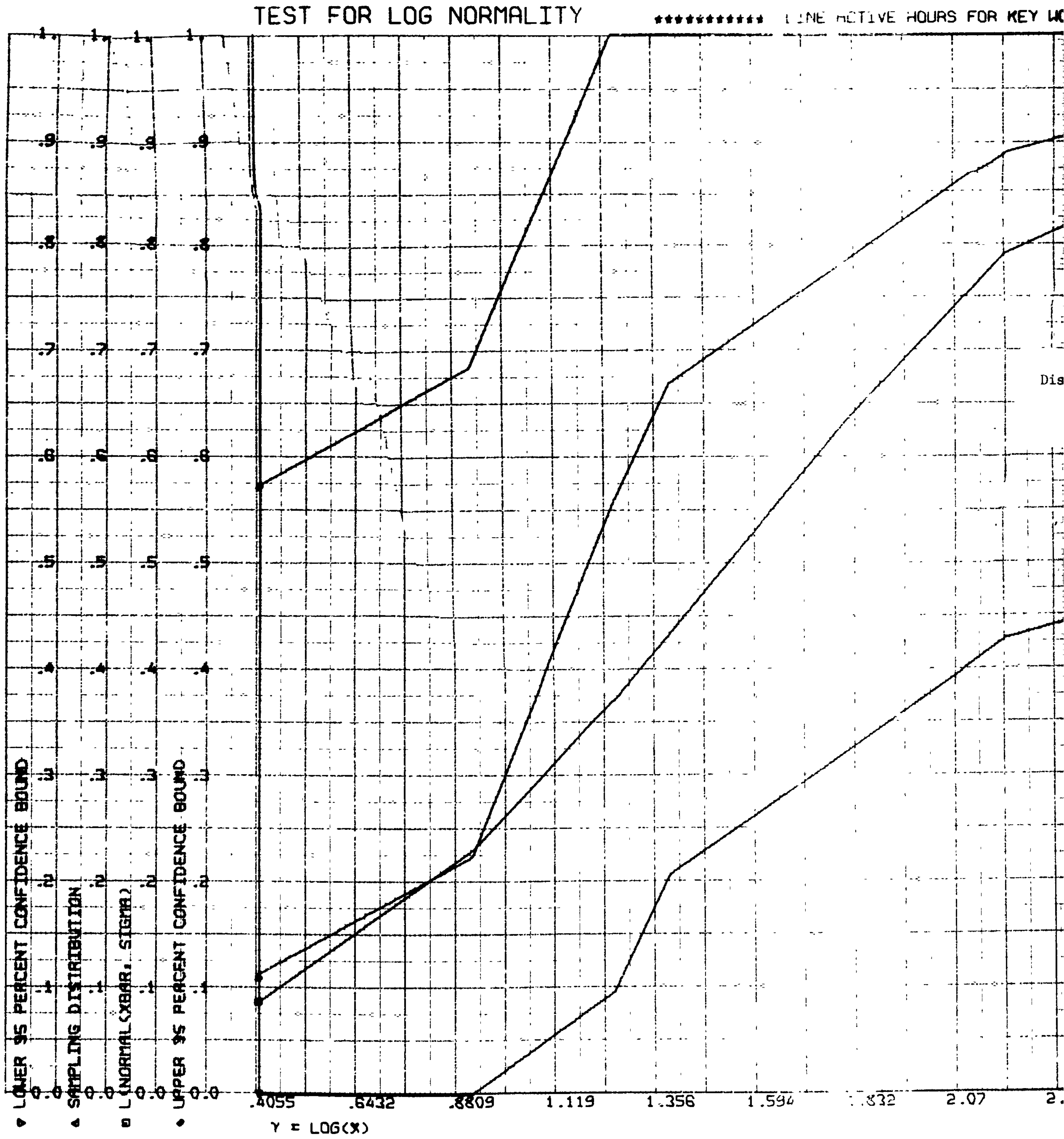


Figure 17 (conc'd)
Distribution of Maintenance Events
Terrain Following Radar
(Total Man-Hours)



*** TOTAL MAN HOURS FOR KEY WORK UNIT CODE 73D **************
1.
.9
.8
.7
.6
.5
.4
.3
.2
.1
0.0
.589
2.045
2.501
2.958
3.414
3.871
4.327
4.783
LOWER 95 PERCENT CONFIDENCE BOUND
SAMPLING DISTRIBUTION
L(NORMAL(XBAR, SIGMA)
UPPER 95 PERCENT CONFIDENCE BOUND



TEST FOR LOG NORMALITY
************ LINE ACTIVE HOURS FOR KEY WO
LOWER 95 PERCENT CONFIDENCE BOUND
SAMPLING DISTRIBUTION
L(NORMAL(XBAR, SIGMA)
UPPER 95 PERCENT CONFIDENCE BOUND
.4055
.6432
.8809
1.119
1.356
1.594
2.07
Y = LOG(X)
Dis

1

**** LINE ACTIVE HOURS FOR KEY WORK UNIT CODE 74AA **************

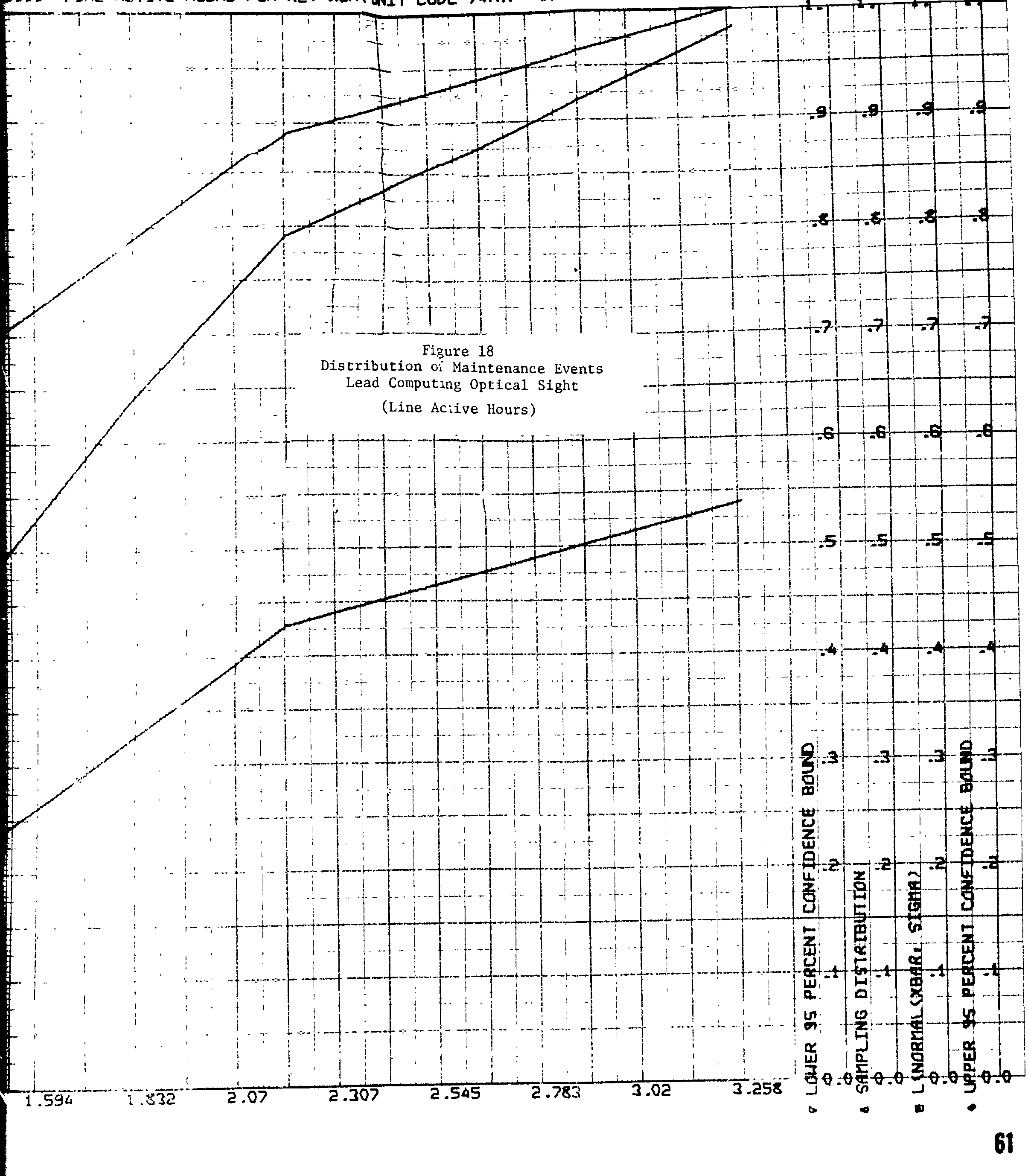


Figure 18
Distribution of Maintenance Events
Lead Computing Optical Sight
(Line Active Hours)

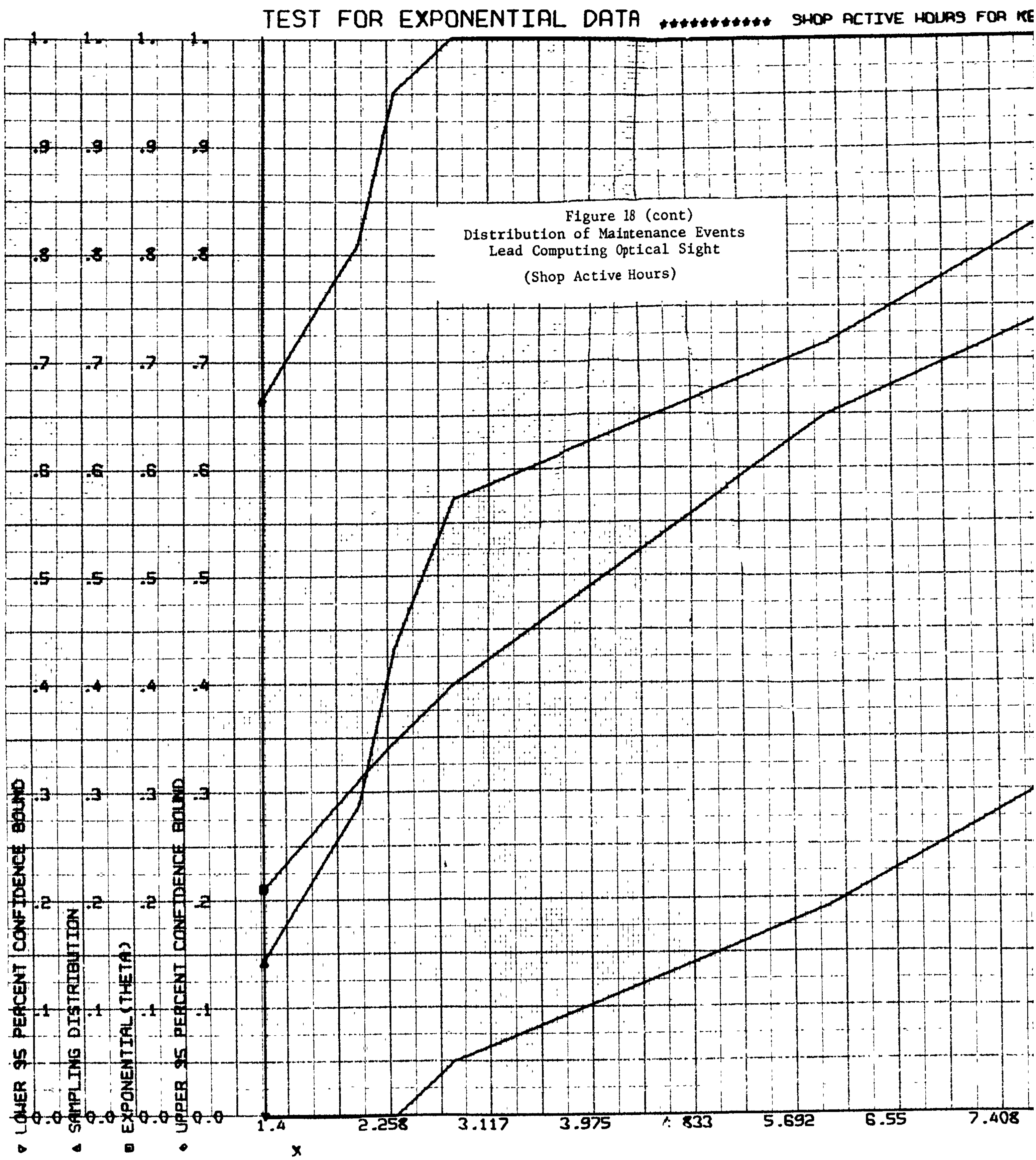
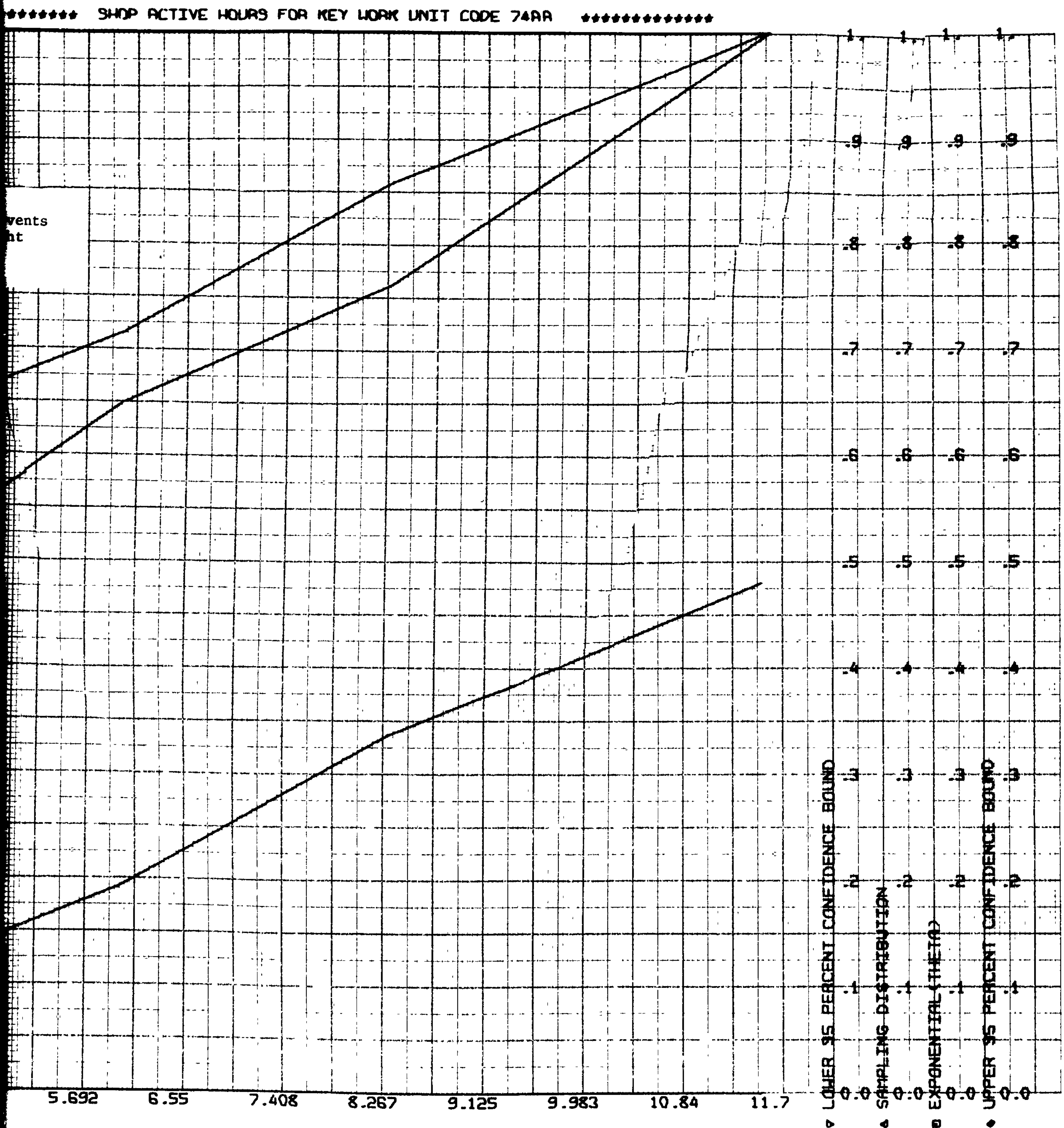
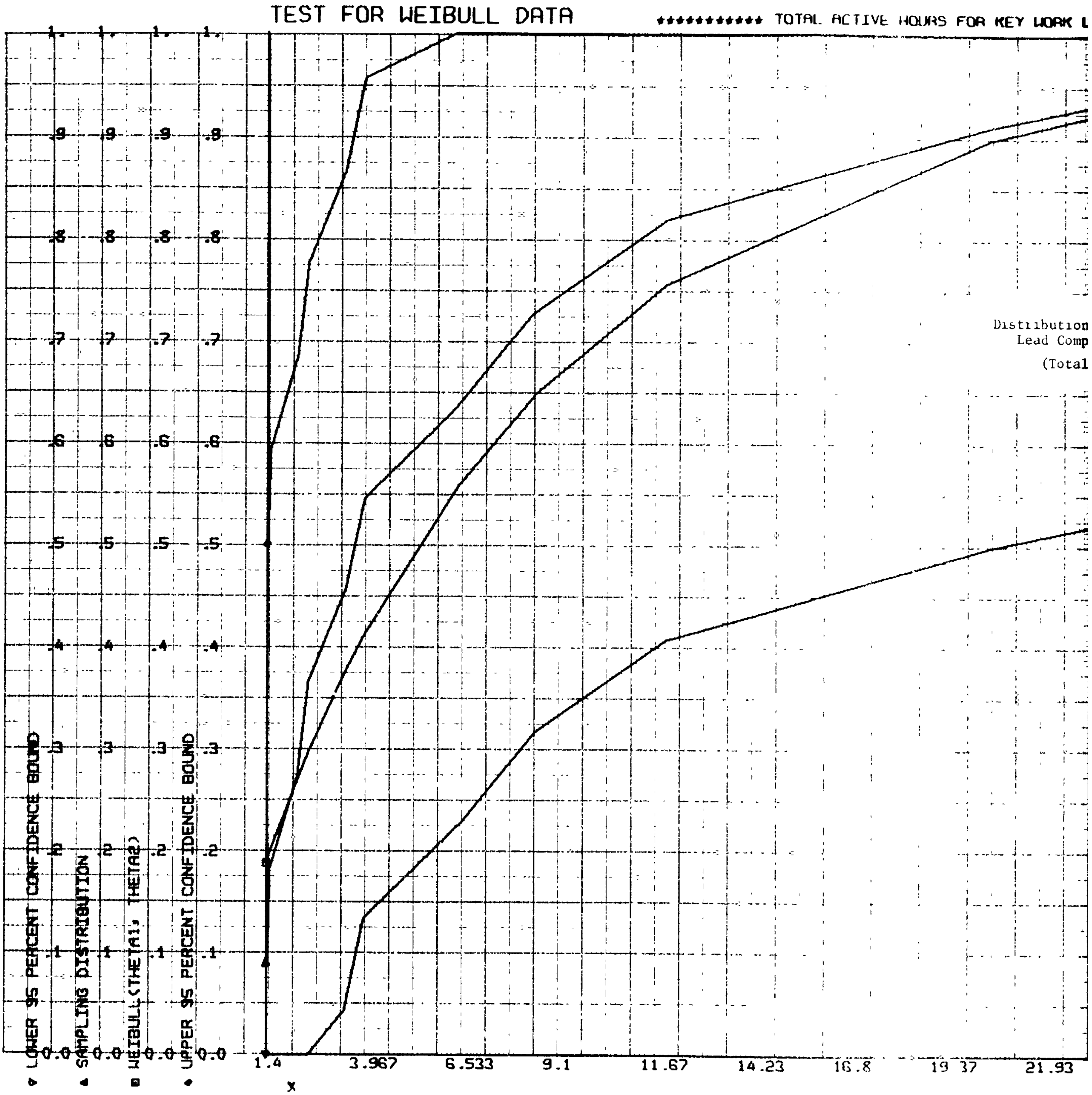


Figure 18 (cont)
Distribution of Maintenance Events
Lead Computing Optical Sight
(Shop Active Hours)


******** SHOP ACTIVE HOURS FOR KEY WORK UNIT CODE 74AA **************
vents
ht
5.692
6.55
7.408
8.267
9.125
9.983
10.84
11.7
LOWER 95 PERCENT CONFIDENCE BOUND
SAMPLING DISTRIBUTION
EXPONENTIAL(THETA)
UPPER 95 PERCENT CONFIDENCE BOUND
0.0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.



TEST FOR WEIBULL DATA
************ TOTAL ACTIVE HOURS FOR KEY WORK L
1.
.9
.8
.7
.6
.5
.4
.3
.2
.1
0.0
1.4
3.967
6.533
9.1
11.67
14.23
16.8
19.37
21.93
X
LOWER 95 PERCENT CONFIDENCE BOUND
SAMPLING DISTRIBUTION
WEIBULL(THETA1, THETA2)
UPPER 95 PERCENT CONFIDENCE BOUND
Distribution
Lead Comp
(Total

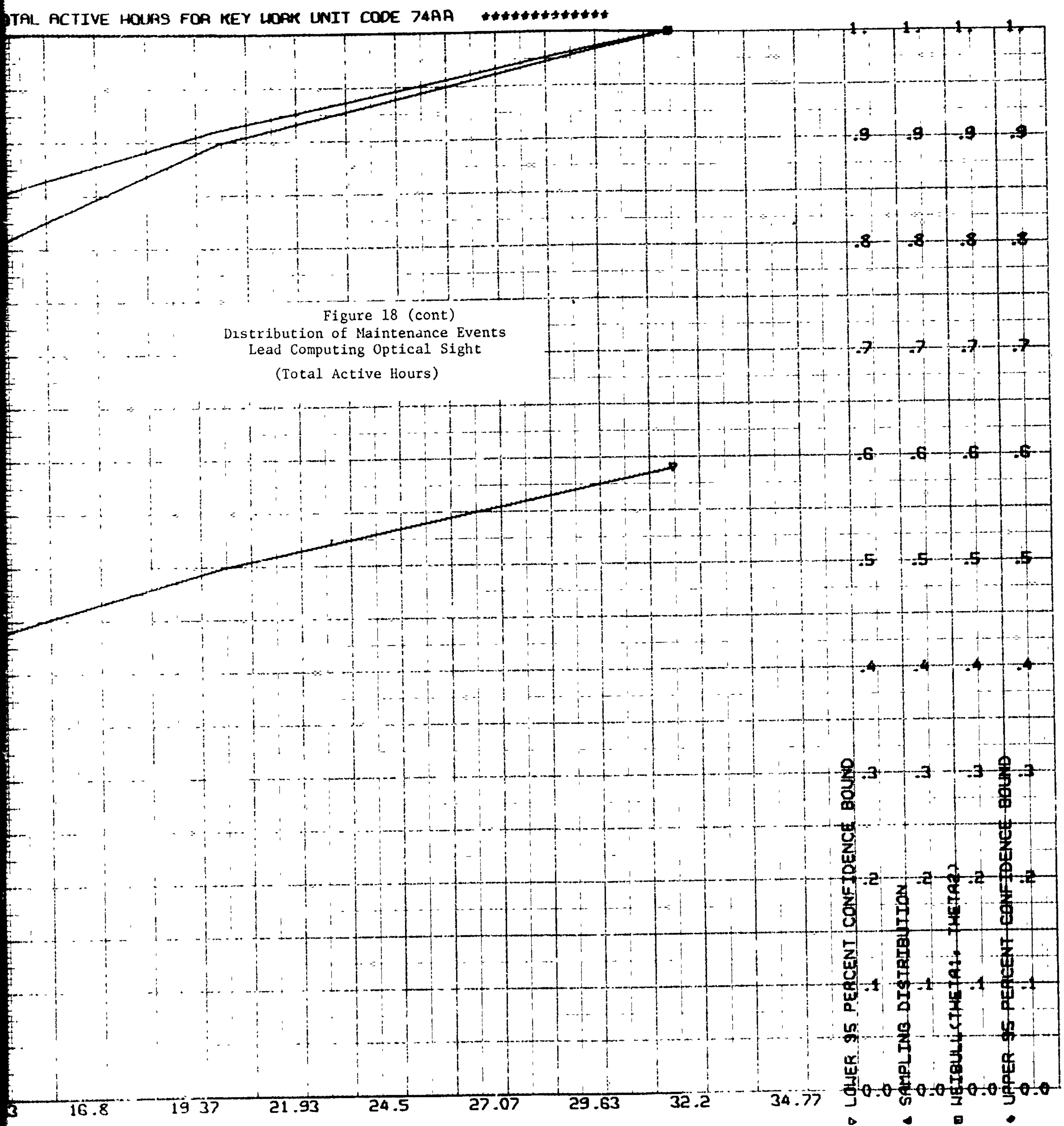


Figure 18 (cont)
Distribution of Maintenance Events
Lead Computing Optical Sight

(Total Active Hours)

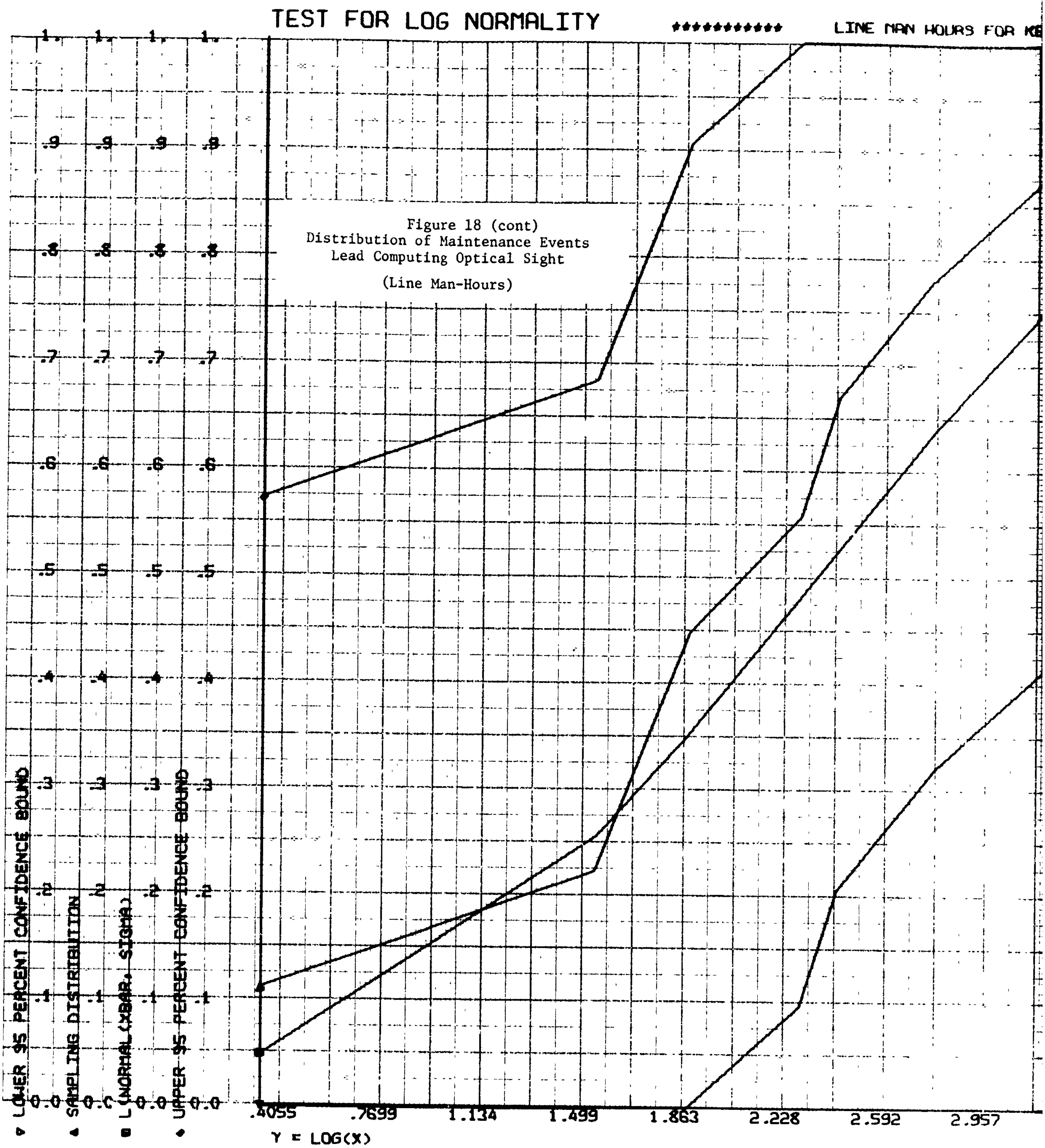
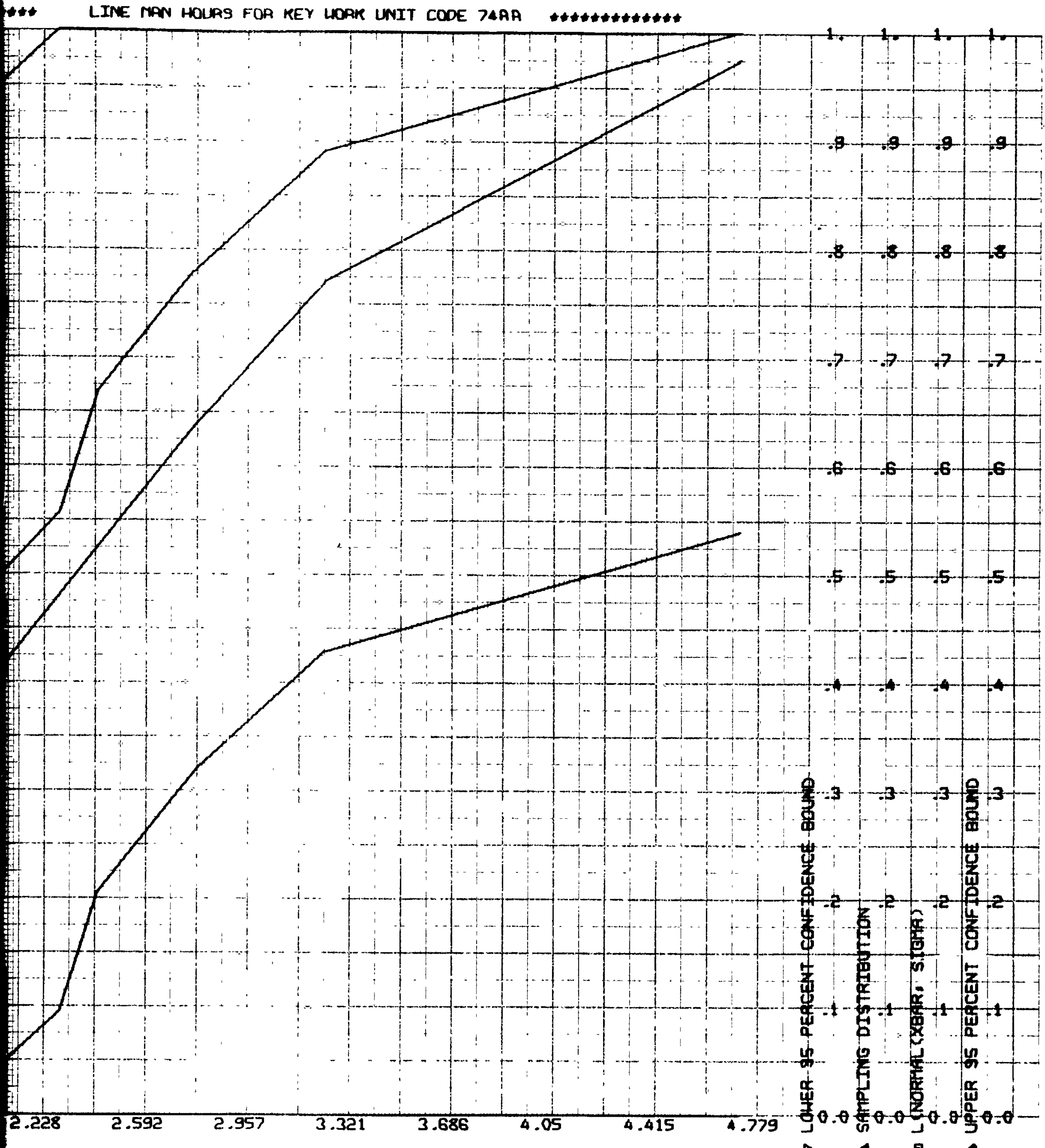


Figure 18 (cont)
Distribution of Maintenance Events
Lead Computing Optical Sight

(Line Man-Hours)



LINE MAN HOURS FOR KEY WORK UNIT CODE 74AA
2.228
2.592
2.957
3.321
3.686
4.05
4.415
4.779
LOWER 95 PERCENT CONFIDENCE BOUND
SAMPLING DISTRIBUTION
L(NORMAL(XBAR, SIGMA)
UPPER 95 PERCENT CONFIDENCE BOUND

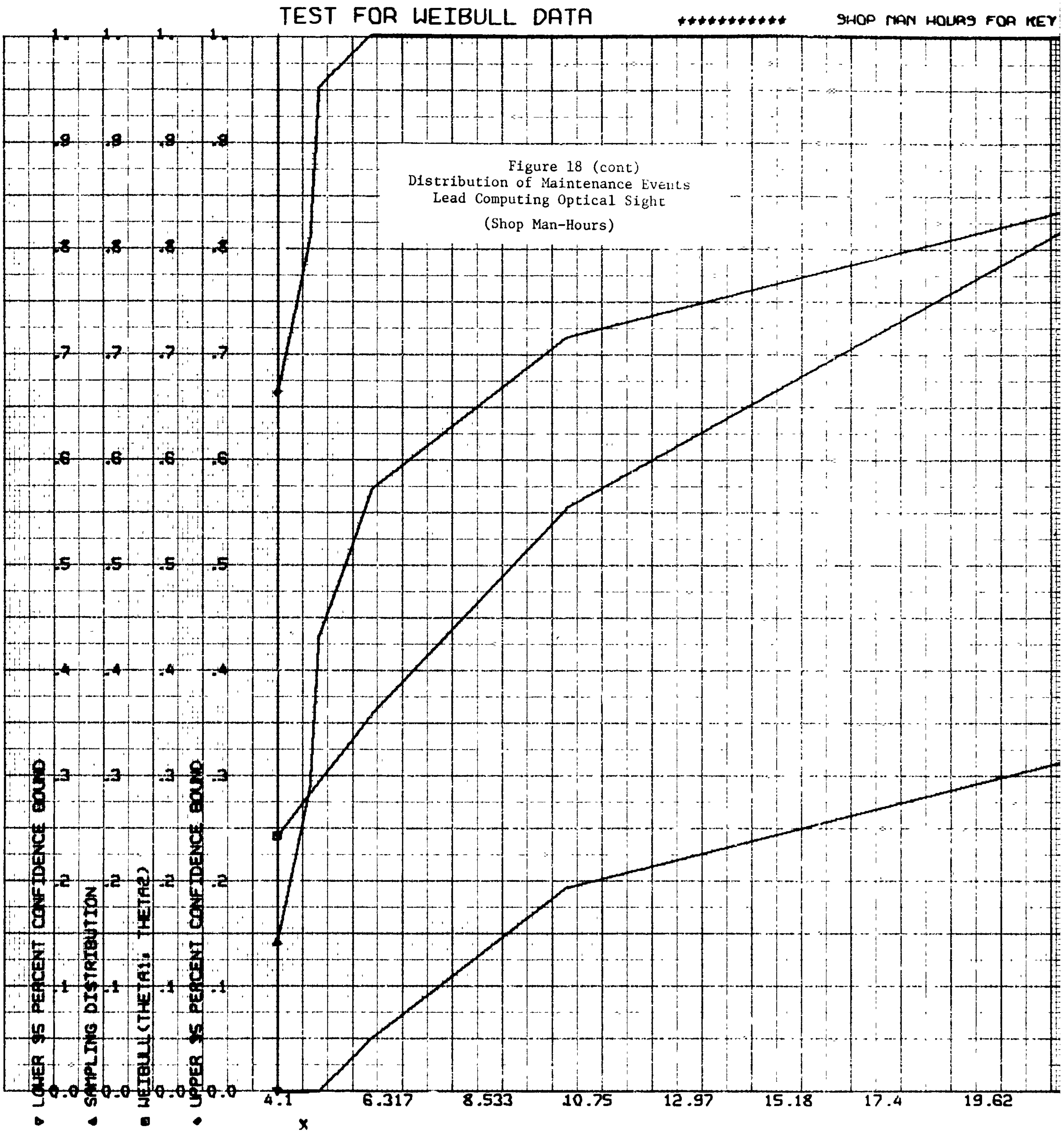
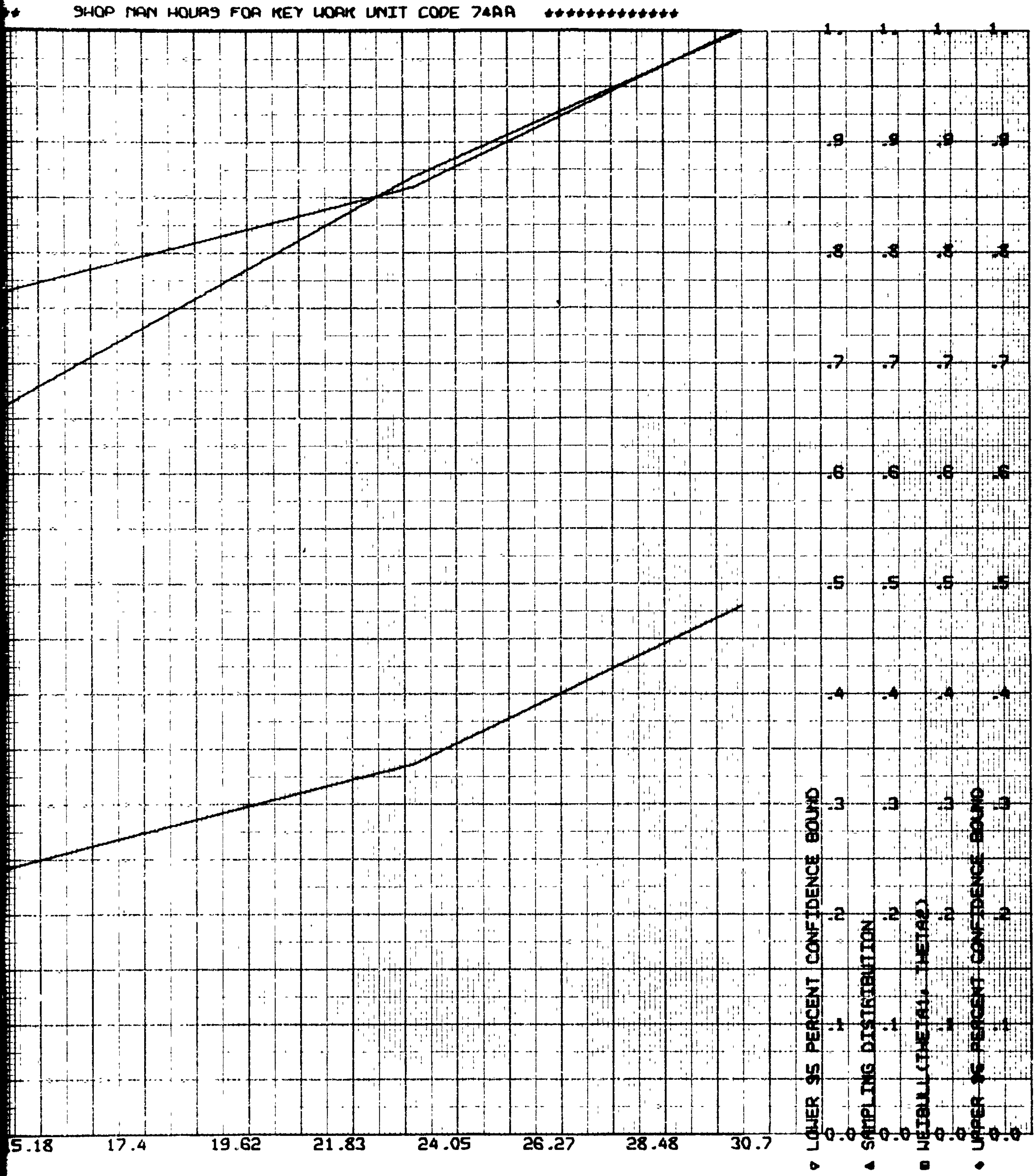


Figure 18 (cont)
Distribution of Maintenance Events
Lead Computing Optical Sight
(Shop Man-Hours)


SHOP MAN HOURS FOR KEY WORK UNIT CODE 74AA
5.18
17.4
19.62
21.83
24.05
26.27
28.48
30.7
LOWER 95 PERCENT CONFIDENCE BOUND
SAMPLING DISTRIBUTION
WEIBULL(THETA1, THETA2)
UPPER 95 PERCENT CONFIDENCE BOUND

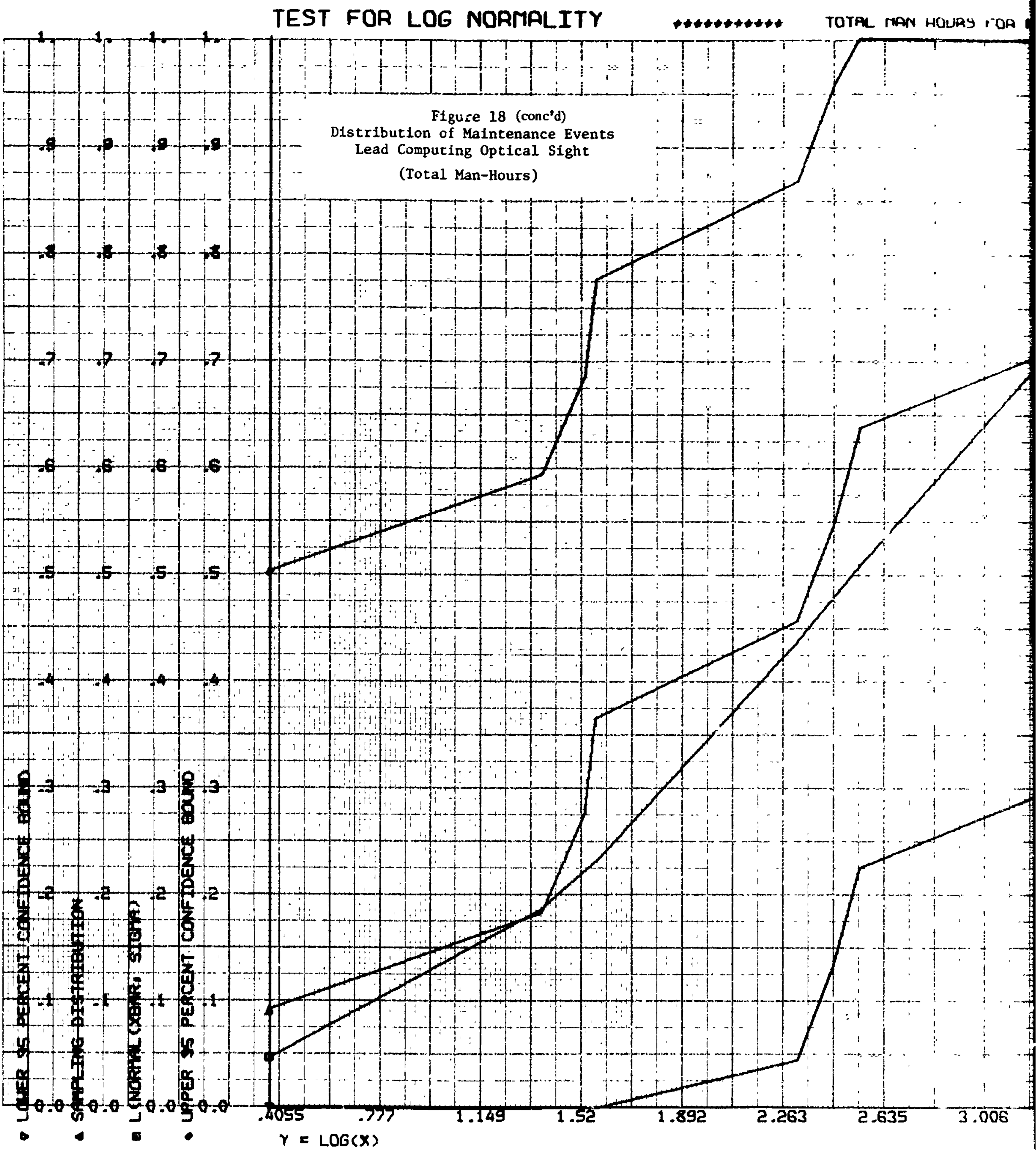


Figure 18 (conc'd)
Distribution of Maintenance Events
Lead Computing Optical Sight
(Total Man-Hours)

AN HOURS FOR KEY WORK UNIT CODE 74AA **************

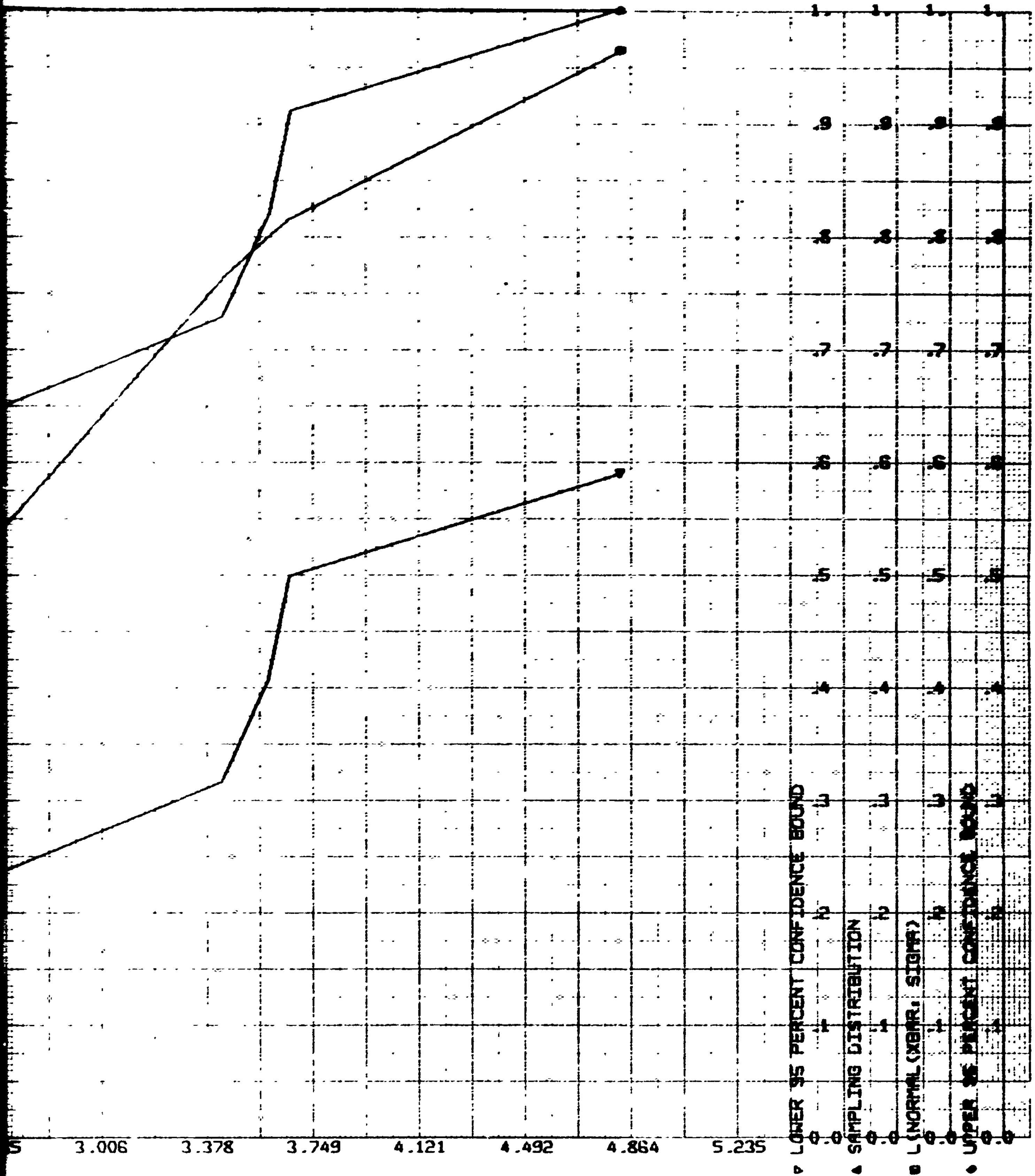


Table I

AIRCRAFT UTILIZATION

Time Period	Jan-Feb 66	Mar 66	Apr 66	May 66	Jun 66	Jul 66	Aug 66	Sep 66	Oct 66	Nov 66	Dec 66	
Hours Flown	30.9	38.9	56.3	35.4	22.6	14.6	24.0	24.6	52.7	14.4	10.5	
Missions Flown[1]	13	16	21	15	23	7	10	11	22	7	5	
Ground Aborts	1	1	0	0	3	0	0	1	2	0	2	
Air Aborts	0	1	1	1	1	1	3	2	2	0	0	
Missions Cancelled-Maintenance	16	24	19	17	17	4	0	7	12	17	17	
Missions Cancelled-Supply	7	9	9	40	0	9	10	4	13	13	13	
In-Commission Rate (pct)	29.5	20.3	23.4	19.6	30.8	9.5	19.2	42	37.3	7.1	14.0	
Number Possessed Aircraft	1	2	2	2	2	2	2	2	2	2	2	
Time Period	Jan 67	Feb 67	Mar 67	Apr 67	May 67	Jun 67	Jul 67	Aug 67	Sep 67	Oct 67	Nov 67	Dec 67
Hours Flown	31.7	52.9	52.0	67.0	97.8	132.7	58.7	73.1	34.4	59.7	38.7	47.8
Missions Flown[1]	15	22	27	29	44	48	28	30	17	26	17	16
Ground Aborts	1	3	2	0	2	4	3	3	1	0	1	2
Air Aborts	2	1	2	1	3	3	3	1	3	4	5	1
Missions Cancelled-Maintenance	24	17	33	11	30	16	30	41	37	48	41	20
Missions Cancelled-Supply	3	1	11	16	7	10	2	9	5	19	19	13
In-Commission Rate (pct)	26.8	57.5	30.1	32.0	36.0	32.6	35	40.4	27.4	24.6	36.4	44.7
Number Possessed Aircraft	3	3	3	3	3	5	5	5	5	5	5	5
Time Period	Jan 68	Feb 68	Mar 68	Apr 68	May 68	Jun 68	Jul 68	Aug 68	Sep 68	Oct 68	Nov 68	Dec 68
Hours Flown	64.5	55.1	46.9	39.8	15.9	54.3	149.3	73.2	41.3	59.7	63.6	38.8
Missions Flown[1]	22	20	20	16	15	23	55	36	27	27	30	15
Ground Aborts	3	3	2	4	1	1	4	0	2	3	5	4
Air Aborts	1	0	1	1	1	1	2	3	2	1	0	2
Missions Cancelled-Maintenance	10	21	25	67	46	30	21	15	16	13	16	7
Missions Cancelled-Supply	29	3	7	12	4	4	13	7	7	9	20	11
In-Commission Rate (pct)	27.0	41.1	33.0	22.0	22.0	16.0	46	26	41	59	34	38
Number Possessed Aircraft	6	5	6	7	8	8	7	6.2	4.7	6.1	5.2	5.4
Time Period	Jan 69	Feb 69	Mar 69	Apr 69	May 69	Jun 69	Jul 69	Aug 69	Sep 69	Oct 69		
Hours Flown	59.9	99.6	110.4	21.2	53.1	66.2	34.4	57.1	56.5	23.8		
Missions Flown[1]	27	44	43	14	32	31	19	33	32	18		
Ground Aborts	5	2	3	0	5	2	3	5	4	0		
Air Aborts	1	1	1	2	1	4	1	0	3	0		
Missions Cancelled-Maintenance	37	34	4	9	27	14	13	32	17	17		
Missions Cancelled-Supply	32	14	0	6	16	6	17	29	7	4		
In-Commission Rate (pct)	37	42	35	16.7	44.3	39.3	27.2	29.5	38.3	27.5		
Number Possessed Aircraft	6	6	5	5.1	5.2	6.6	5.6	4.2	3.6	3.0		

[1] Does not include ground or air aborts.

TABLE II

SUBSYSTEM MISSION MALFUNCTION REPORT
JULY 1968 THRU OCTOBER 1969

	SUCCESS	DEGRADE[1]	FAIL	ABORT	OPERATING TIME[2] (HRS)
AIRFRAME	459	22	1	4	950.08
LANDING GEAR	462	8	3	11	947.41
FLIGHT CONTROL	431	40	8	18	950.08
ESCAPE CAPSULE	459	8	2	1	919.73
ENGINES	403	70	4	29	945.41
AIR COND, PRESS	458	23	2	2	946.16
ELECTRICAL PWR	479	6	0	2	950.08
LIGHTNING SYSTM	435	6	1	0	866.48
HYD,PNEUM PWR	482	2	1	3	947.33
FUEL	451	31	2	7	947.91
AIR REFUELING	26	2	0	1	86.00
OXYGEN SYSTEM	475	7	0	0	947.75
MISC UTILITIES	434	2	0	0	662.66
INSTRUMENTS	432	46	5	3	947.58
AUTO PILOT	326	24	9	0	744.84
AIR DATA	414	8	2	2	845.46
HF COMM	24	0	1	0	62.34
UHF COMM	466	11	3	0	940.61
INTERPHONE	473	9	1	1	947.75
IFF/SIF	403	5	14	0	836.64
MISC COMM	425	1	0	0	838.51
TACAN	402	11	10	0	830.69
ILAS	50	6	1	0	107.49
UHF/ADF	32	0	0	0	68.84
INERIAL NAV	353	45	10	1	882.41
ATTACK RADAR	252	62	21	1	643.31
RADAR ALTIMETER	383	22	7	0	618.83
TFR	107	19	5	0	255.59
LCOS	270	10	0	0	554.80
BOMB TIMER	26	0	0	0	48.43
WEAPONS BAY GUN	6	2	0	1	17.58
PYLONS	53	0	0	0	79.90
WEAPONS BAY	22	0	0	0	35.03
WEAPONS CONTROL	53	1	0	1	76.57
WEAPONS RACKS	42	2	1	0	65.49
CMRS	10	0	0	0	22.25
RHAWS	13	4	0	0	34.09
INSTRUMENTATION	172	9	7	3	380.44

[1]Degrade – The number of mission the subsystem had to be operated in a degraded mode.

[2]Operating Time – The total flying time of the mission on which the subsystem was used.

TABLE III
SUBSYSTEM MISSION RELIABILITY REPORT
JULY 1968 THRU OCTOBER 1969

	MEAN TIME BETWEEN DISCREPANCY		MEAN TIME BETWEEN FAILURE		MEAN TIME BETWEEN ABORT	
	MEASURED	90 PERCENT LOWER CONFIDENCE LIMIT	MEASURED	90 PERCENT LOWER CONFIDENCE LIMIT	MEASURED	90 PERCENT LOWER CONFIDENCE LIMIT
AIRFRAME	35.2	27.2	190.0	102.4	237.5	118.9
LANDING GEAR	43.1	32.3	67.7	47.1	86.1	57.1
FLIGHT CONTROL	14.4	12.2	36.5	28.1	52.8	38.4
ESCAPE CAPSULE	83.0	55.4	306.6	137.7	919.7	236.5
ENGINES	9.2	8.1	28.6	22.7	32.6	25.4
AIR COND, PRESS	35.0	27.1	236.5	118.4	473.1	177.8
ELECTRICAL PWR	116.8	73.1	475.0	178.5	475.0	178.5
LIGHTNING SYSTM	123.6	73.6	866.5	222.8	NO ABORT	376.3
HYD, PNEUM PWR	157.9	89.9	236.8	118.5	315.8	141.6
FUEL	23.7	19.2	105.3	66.7	135.4	80.5
AIR REFUELING	28.7	12.9	86.0	22.1	86.0	22.1
OXYGEN SYSTEM	135.4	80.5	NO FAIL	411.6	NO ABORT	411.6
MISC UTILITIES	431.3	162.1	NO FAIL	374.7	NO ABORT	374.7
INSTRUMENTS	17.5	14.6	118.4	72.9	315.9	141.6
AUTO PILOT	22.6	17.9	82.8	52.4	NO ABORT	323.5
AIR DATA	70.5	47.5	211.4	105.8	422.7	158.9
HF COMM	62.3	16.0	62.3	16.0	NO ABORT	27.1
UHF COMM	67.2	46.7	313.5	140.8	NO ABORT	408.5
INTERPHONE	86.2	57.1	473.9	178.1	947.7	243.7
IFF/SIF	44.0	32.3	59.8	41.6	NO ABORT	363.4
MISC COMM	638.5	215.6	NO FAIL	364.2	NO ABORT	364.2
TACAN	39.6	29.5	83.1	53.9	NO ABORT	360.8
ILAS	15.4	9.1	107.5	27.6	NO ABORT	46.7
UHF/ADF	NO DISC	29.9	NO FAIL	29.9	NO ABORT	29.9
INERTIAL NAV	15.8	13.2	80.2	53.2	882.4	226.9
ATTACK RADAR	7.7	6.6	29.2	21.9	643.3	165.4
RADAR ALTIMETER	28.2	22.0	117.0	69.6	NO ABORT	355.6
TFR	10.6	8.1	51.1	27.6	NO ABORT	111.0
LCOS	55.5	36.0	NO FAIL	241.0	NO ABORT	241.0
BOMB TIMER	NO DISC	21.0	NO FAIL	21.0	NO ABORT	21.0
WEAPONS BAY GUN	5.9	2.6	17.6	4.5	17.6	4.5
PYLONS	NO DISC	34.7	NO FAIL	34.7	NO ABORT	34.7
WEAPONS BAY	NO DISC	15.2	NO FAIL	15.2	NO ABORT	15.2
WEAPONS CONTROL	38.3	14.4	76.6	19.7	76.6	19.7
WEAPONS RACKS	21.8	9.8	65.5	16.8	NO ABORT	28.4
CMRS	NO DISC	9.7	NO FAIL	9.7	NO ABORT	5.7
RHAWS	8.5	4.3	NO FAIL	14.8	NO ABORT	14.8
INSTRUMENTATION	20.0	14.7	38.0	24.7	126.8	56.9

TABLE III (Concluded)
SUBSYSTEM MISSION RELIABILITY REPORT
JULY 1968 THRU OCTOBER 1969

	PROBABILITY OF NO DISCREPANCY		PROBABILITY OF NO FAILURE		PROBABILITY OF NO ABORT	
	MEASURED	90 PERCENT LOWER CONFIDENCE LIMIT	MEASURED	90 PERCENT LOWER CONFIDENCE LIMIT	MEASURED	90 PERCENT LOWER CONFIDENCE LIMIT
AIRFRAME	0.94	0.93	0.99	0.98	0.99	0.98
LANDING GEAR	0.95	0.94	0.97	0.96	0.98	0.97
FLIGHT CONTROL	0.87	0.85	0.95	0.93	0.96	0.95
ESCAPE CAPSULE	0.98	0.97	0.99	0.99	1.00	0.99
ENGINES	0.80	0.77	0.93	0.92	0.94	0.93
AIR COND. PRESS	0.94	0.93	0.99	0.98	1.00	0.99
ELECTRICAL PWR	0.98	0.97	1.00	0.99	1.00	0.99
LIGHTNING SYSTM	0.98	0.97	1.00	0.99	1.00	1.00
HYD.PNEUM PWR	0.99	0.98	0.99	0.96	0.99	0.99
FUEL	0.92	0.90	0.98	0.97	0.99	0.98
AIR REFUELING	0.90	0.75	0.97	0.85	0.97	0.85
OXYGEN SYSTEM	0.99	0.98	1.00	1.00	1.00	1.00
MISC UTILITIES	1.00	0.99	1.00	1.00	1.00	1.00
INSTRUMENTS	0.89	0.87	0.98	0.97	0.99	0.99
AUTO PILOT	0.91	0.89	0.97	0.96	1.00	1.00
AIR DATA	0.97	0.96	0.99	0.98	1.00	0.99
HF COMM	0.96	0.82	0.96	0.82	1.00	0.89
UHF COMM	0.97	0.96	0.99	0.99	1.00	1.00
INTERPHONE	0.98	0.97	1.00	0.99	1.00	0.99
IFF/SIF	0.95	0.94	0.97	0.95	1.00	1.00
MISC COMM	1.00	0.99	1.00	1.00	1.00	1.00
TACAN	0.95	0.93	0.98	0.96	1.00	1.00
ILAS	0.88	0.95	0.98	0.95	1.00	0.95
UHF/ADF	1.00	0.91	1.00	0.91	1.00	0.91
INERIAL NAV	0.88	0.85	0.98	0.96	1.00	0.99
ATTACK RADAR	0.75	0.72	0.93	0.92	1.00	0.99
RADAR ALTIMETER	0.93	0.91	0.98	0.97	1.00	1.00
TFR	0.82	0.77	0.96	0.93	1.00	0.99
LCOS	0.96	0.95	1.00	0.99	1.00	0.99
BOMB TIMER	1.00	0.89	1.00	0.89	1.00	0.89
WEAPONS BAY GUN	0.73	0.43	0.91	0.64	0.91	0.64
PYLONS	1.00	0.94	1.00	0.94	1.00	0.94
WEAPONS BAY	1.00	0.87	1.00	0.87	1.00	0.87
WEAPONS CONTROL	0.96	0.95	0.98	0.95	0.98	0.95
WEAPONS RACKS	0.93	0.93	0.98	0.93	1.00	0.94
CMRS	1.00	0.74	1.00	0.74	1.00	0.74
RHAWS	0.76	0.54	1.00	0.84	1.00	0.84
INSTRUMENTATION	0.90	0.87	0.95	0.92	0.98	0.97

Table IV

CEI/ALLOTTED MTBF AND MEASURED MTBF COMPARISON

Subsystem	CEI/Allotted MTBF	Measured MTBF	Comment
Airframe	1600	190.0	A large contributor to the difference was the large number of wing seal failures recorded during Category II testing.
Flight Control	180	36.5	During Category II testing there were numerous failures on the flaps and slats. Also the feel and trim assembly was a leading contributor to the low MTBF measured.
Escape Capsule	---	306.6	The failures recorded against the capsule were due to windshield and canopy failures.
Air Conditioning and Pressurization	435	236.8	---
Fuel System	---	105.3	The low MTBF recorded was caused by the large number of failures recorded against the fuel probes.
IFF	400	59.8	During Category II testing the IFF was operated 836 hours and had 14 failures. The majority of these were transmitter-receiver failures. Others were caused by loose and broken antenna cables.
Interphone	1000	473.9	The interphone was used for 948 hours and had two failures. Both failures were in the interphone control box.
Tacan	---	83.1	During Category II testing there were ten failures recorded during 831 hours of operation. The majority of these failures were in the Tacan transmitter-receiver unit.
UHF Communications	220	313.5	The UHF communication was GFAE hardware. The subsystem was operated for 940 hours and had three failures. These failures were in the receiver/transmitter unit. The UHF was the only subsystem with a large amount of operating time that surpassed the specified MTBF.
ILAS	300	107.5	This subsystem was not used extensively, which could contribute to the low MTBF. The ILAS had only one failure in 107.5 hours. This was also GFAE hardware.
Inertial Navigation	243	80.2	The inertial reference unit (stabilization platform) had the highest failure rate in this subsystem. The platform had seven of the ten failures shown in table IV.
Attack Radar	134	29.2	The attack radar had lowest reliability of all the avionic subsystems. The receiver/transmitter, the synchronizer, and the antenna indicator control unit had the highest failure rates. The attack radar was operated 643 hours and had 22 failures.
Radar Altimeter	500	117.0	The radar altimeter had trouble with the receiver/transmitter developing internal lock, which caused the altitude reading to remain constant. There were also complete failures of the altimeter.
Terrain Following Radar	108	50.1	The receiver/transmitter, antennas, and computers were the high failure items. The TFR was operated for 256 hours and had five failures.
LCOS	300	241.0	The LCOS did not have a failure in 555 hours of operation. The measured value presented is the 90-percent lower confidence limit from table IV.
Bomb Timer	1000	21.0	The bomb timer had a low utilization rate which could contribute to the low MTBF. This was also GFAE hardware.
CMRS	150	9.7	The CMRS did not have a failure in 22.3 hours of operation. The value presented is the 90-percent lower confidence limit from table IV. As can be seen in table IV, the CMRS had a very low utilization rate.
RHAWS	152	14.8	The RHAWS did not have a failure in 34.1 hours of operation. The measured value presented in the 90-percent lower confidence limit from table IV. The RHAWS also had a low utilization rate as can be seen in table IV.

TABLE V
MAINTENANCE MAN-HOURS PER FLYING HOUR BY WORK UNIT CODE
(SUPPORT GENERAL MAINTENANCE)
OCTOBER 1969

		LINE		SHOP		TOTAL	
TITLE	WUC	MMH/FH	PERCENT OF TOTAL	MMH/FH	PERCENT OF TOTAL	MMH/FH	PERCENT OF TOTAL
GND HANDLING,SERVICE,FLY	1	7.2	8.0	0.	0.	7.2	8.0
AIRCRAFT CLEANING	2	1.1	1.2	0.	0.	1.1	1.2
LOOK PHASE OF INSPECTION	3	11.6	12.9	1.3	1.5	13.0	14.4
SPECIAL INSPECTIONS	4	1.6	1.7	0.3	0.4	1.9	2.1
A/C AND ENGINE STORAGE	5	0.	0.	0.	0.	0.	0.
GROUND SAFETY	6	0.1	0.1	0.	0.	0.1	0.1
PREPARATION A/C RECORDS	7	0.2	0.2	0.	0.	0.2	0.2
SPECIAL WPNS HANDLING	8	0.	0.	0.	0.	0.	0.
SHOP SUPPORT GENERAL	9	0.5	0.6	0.	0.	0.5	0.6
TOTALS FOR SUPPORT GENERAL		22.2	24.7	1.7	1.9	23.9	26.6

TABLE V (Continued)
MAINTENANCE MAN-HOURS PER FLYING HOUR BY WORK UNIT CODE
(NON-SUPPORT GENERAL MAINTENANCE)
OCTOBER 1969

TITLE	WUC	------LINE------		------SHOP------		------TCTAL-----	
		MMH/FH	PERCENT OF TOTAL	MMH/FH	PERCENT OF TOTAL	MMH/FH	PERCENT OF TOTAL
AIPFRAME	11	10.4	11.6	0.7	0.8	11.1	12.4
LANDING GEAR	13	5.9	6.6	0.5	0.5	6.4	7.1
FLIGHT CONTROL	14	6.8	7.5	0.	0.	6.8	7.5
ESCAPE CAPSULE	16	7.2	8.1	0.	0.	7.2	8.1
TURBC JET POWER PLANT	23	1.6	1.8	0.7	0.8	2.3	2.6
AIR CCNDITICN,PRESSURE	41	0.0	0.0	0.	0.	0.0	0.0
ELECTRICAL POWER SUPPLY	42	0.2	0.2	0.1	0.1	0.3	0.3
LIGHTING SYSTEM	44	1.1	1.2	0.	0.	1.1	1.2
PNEUCRAULIC PCWER SUPPLY	45	1.2	1.4	0.3	0.4	1.5	1.7

TABLE V (Continued)
MAINTENANCE MAN-HOURS PER FLYING HOUR BY WORK UNIT CODE
(NON-SUPPORT GENERAL MAINTENANCE)
OCTOBER 1969

TITLE	WUC	LINE MMH/FH	LINE PERCENT OF TOTAL	SHOP MMH/FH	SHOP PERCENT OF TOTAL	TOTAL MMH/FH	TOTAL PERCENT OF TOTAL
FUEL SYSTEM	46	2.2	2.5	0.	0.	2.2	2.5
OXYGEN SYSTEM	47	1.0	1.1	0.	0.	1.0	1.1
MISCELLANEOUS UTILITIES	49	0.3	0.4	0.	0.	0.3	0.4
INSTRUMENTS	51	0.1	0.1	0.1	0.1	0.2	0.2
AUTOPILOT	52	4.3	4.8	1.5	1.6	5.8	6.4
MALFUNCTION ANALYSIS	55	0.	0.	0.	0.	0.	0.
HF COMMUNICATIONS	61	0.0	0.0	0.2	0.2	0.2	0.2
UHF COMMUNICATIONS	63	0.0	0.0	0.	0.	0.0	0.0
INTERPHONE	64	0.0	0.0	0.	0.	0.0	0.0
IFF/SIF	65	0.1	0.1	0.3	0.3	0.4	0.4

TABLE V (Concluded)
MAINTENANCE MAN-HOURS PER FLYING HOUR BY WORK UNIT CODE
(NON-SUPPORT GENERAL MAINTENANCE)
OCTOBER 1969

TITLE	WUC	LINE MMH/FH	LINE PERCENT OF TOTAL	SHCP MMH/FH	SHCP PERCENT OF TOTAL	TOTAL MMH/FH	TOTAL PERCENT OF TOTAL
MISC COMM EQUIPMENT	69	0.	0.	0.	0.	0.	0.
RADIO NAVIGATION	71	0.1	0.1	0.6	0.6	0.6	0.7
BOMBING NAVIGATION	73	1.4	1.6	6.3	7.0	7.7	8.6
FIRE CONTROL	74	1.2	1.3	0.	0.	1.2	1.3
WEAPONS DELIVERY	75	3.2	3.5	0.	0.	3.2	3.5
ELECTRONIC COUNTERMEASUR	76	0.	0.	0.	0.	0.	0.
ECM EQUIPMENT	86	0.	0.	0.	0.	0.	0.
PERSONNEL EQUIPMENT	96	0.	0.	0.	0.	0.	0.
EXPLOSIVE DEVICES	97	6.4	7.1	0.	0.	6.4	7.1
TOTALS FOR NONSUPPORT GENERAL		54.9	61.1	11.1	12.3	65.9	73.4
F111A AIRCRAFT TOTALS		77.1		12.8		89.8	

TABLE VI
MAINTENANCE MAN-HOURS PER FLYING HOUR BY WORK UNIT CODE
(SUPPORT GENERAL MAINTENANCE)
MAY 1969 THRU OCTOBER 1969

TITLE	WUC	LINE MMH/FH	LINE PERCENT OF TOTAL	SHOP MMH/FH	SHOP PERCENT OF TOTAL	TOTAL MMH/FH	TOTAL PERCENT OF TOTAL
GND HANDLING,SERVICE,FLY	1	7.7	10.4	0.1	0.1	7.8	10.4
AIRCRAFT CLEANING	2	0.5	0.7	0.	0.	0.5	0.7
LOOK PHASE OF INSPECTION	3	8.2	11.1	5.2	6.9	13.4	18.0
SPECIAL INSPECTIONS	4	2.7	3.6	0.5	0.7	3.3	4.4
A/C AND ENGINE STORAGE	5	0.	0.	0.1	0.2	0.1	0.2
GROUND SAFETY	6	0.0	0.0	0.	0.	0.0	0.0
PREPARATION A/C RECORDS	7	0.1	0.1	0.	0.	0.1	0.1
SPECIAL WPNS HANDLING	8	0.	0.	0.	0.	0.	0.
SHOP SUPPORT GENERAL	9	0.1	0.1	8.4	11.3	8.5	11.4
TOTALS FOR SUPPORT GENERAL		19.3	26.0	14.3	19.3	33.7	45.3

TABLE VI (Continued)
MAINTENANCE MAN-HOURS PER FLYING HOUR BY WORK UNIT CODE
(NON-SUPPORT GENERAL MAINTENANCE)
MAY 1969 THRU OCTOBER 1969

TITLE	WUC	LINE MMH/FH	LINE PERCENT OF TOTAL	SHOP MMH/FH	SHOP PERCENT OF TOTAL	TOTAL MMH/FH	TOTAL PERCENT OF TOTAL
AIRFRAME	11	3.3	4.4	0.4	0.5	3.7	4.9
LANDING GEAR	13	4.1	5.5	0.5	0.7	4.6	6.2
FLIGHT CONTROL	14	3.6	4.9	0.1	0.2	3.7	5.0
ESCAPE CAPSULE	16	1.2	1.6	0.0	0.0	1.2	1.6
TURBO JET POWER PLANT	23	7.4	9.9	2.3	3.0	9.6	13.0
AIR CONDITION,PRESSURE	41	0.1	0.1	0.	0.	0.1	0.1
ELECTRICAL POWER SUPPLY	42	0.4	0.5	0.2	0.2	0.6	0.8
LIGHTING SYSTEM	44	0.2	0.2	0.0	0.0	0.2	0.2
PNEUDRAULIC POWER SUPPLY	45	0.8	1.0	0.0	0.1	0.8	1.1

TABLE VI (Continued)
MAINTENANCE MAN-HOURS PER FLYING HOUR BY WORK UNIT CODE
(NON-SUPPORT GENERAL MAINTENANCE)
MAY 1969 THRU OCTOBER 1969

TITLE	WUC	------LINE------		------SHOP------		------TOTAL------	
		MMH/FH	PERCENT OF TOTAL	MMH/FH	PERCENT OF TOTAL	MMH/FH	PERCENT OF TOTAL
FUEL SYSTEM	46	2.0	2.7	0.1	0.1	2.1	2.8
OXYGEN SYSTEM	47	0.1	0.2	0.0	0.0	0.1	0.2
MISCELLANEOUS UTILITIES	49	0.1	0.1	0.	0.	0.1	0.1
INSTRUMENTS	51	0.3	0.4	0.4	0.5	0.7	0.9
AUTOPILOT	52	1.4	1.8	0.9	1.2	2.2	3.0
MALFUNCTION ANALYSIS	55	0.	0.	0.	0.	0.	0.
HF COMMUNICATIONS	61	0.0	0.0	0.0	0.0	0.0	0.0
UHF COMMUNICATIONS	63	0.1	0.1	0.0	0.0	0.1	0.1
INTERPHONE	64	0.0	0.0	0.0	0.0	0.0	0.0
IFF/SIF	65	0.1	0.1	0.1	0.1	0.2	0.2

TABLE VI (Concluded)
MAINTENANCE MAN-HOURS PER FLYING HOUR BY WORK UNIT CODE
(NON-SUPPORT GENERAL MAINTENANCE)
MAY 1969 THRU OCTOBER 1969

TITLE	WUC	------LINE------ MMH/FH	PERCENT OF TOTAL	------SHOP------ MMH/FH	PERCENT OF TOTAL	------TOTAL------ MMH/FH	PERCENT OF TOTAL
MISC COMM EQUIPMENT	69	0.0	0.0	0.	0.	0.0	0.0
RADIO NAVIGATION	71	0.1	0.1	0.3	0.4	0.4	0.5
BOMBING NAVIGATION	73	1.8	2.5	4.0	5.4	5.9	7.9
FIRE CONTROL	74	1.1	1.5	0.3	0.4	1.4	1.8
WEAPONS DELIVERY	75	1.7	2.2	0.1	0.2	1.8	2.4
ELECTRONIC COUNTERMEASUR	76	0.0	0.0	0.	0.	0.0	0.0
ECM EQUIPMENT	86	0.	0.	0.	0.	0.	0.
PERSONNEL EQUIPMENT	96	0.0	0.0	0.	0.	0.0	0.0
EXPLOSIVE DEVICES	97	0.9	1.2	0.	0.	0.9	1.2
		-----	-----	-----	-----	-----	-----
TOTALS FOR NUNSUPPORT GENERAL		30.8	41.5	9.8	13.2	40.6	54.7
F111A AIRCRAFT TOTALS		50.1		24.1		74.2	

TABLE VII
MAINTENANCE MAN-HOURS PER FLYING HOUR BY WORK UNIT CODE
(SUPPORT GENERAL MAINTENANCE)
NOVEMBER 1968 THRU OCTOBER 1969

		------LINE------		------SHOP------		------TOTAL-----	
TITLE	WUC	MMH/FH	PERCENT OF TOTAL	MMH/FH	PERCENT OF TOTAL	MMH/FH	PERCENT OF TOTAL
GND HANDLING,SERVICE,FLY	1	7.8	9.4	0.0	0.0	7.8	9.5
AIRCRAFT CLEANING	2	0.4	0.5	0.	0.	0.4	0.5
LOOK PHASE OF INSPECTION	3	8.9	10.8	5.7	7.0	14.6	17.8
SPECIAL INSPECTIONS	4	2.8	3.4	0.6	0.7	3.4	4.1
A/C AND ENGINE STORAGE	5	0.	0.	0.1	0.2	0.1	0.2
GROUND SAFETY	6	0.0	0.0	0.	0.	0.0	0.0
PREPARATION A/C RECORDS	7	0.1	0.1	0.	0.	0.1	0.1
SPECIAL WPNS HANDLING	8	0.	0.	0.	0.	0.	0.
SHOP SUPPORT GENERAL	9	0.1	0.1	12.3	14.9	12.3	15.0
TOTALS FOR SUPPORT GENERAL		20.0	24.4	18.8	22.8	38.8	47.2

TABLE VII (Continued)
MAINTENANCE MAN-HOURS PER FLYING HOUR BY WORK UNIT CODE
(NON-SUPPORT GENERAL MAINTENANCE)
NOVEMBER 1968 THRU OCTOBER 1969

TITLE	WUC	LINE MMH/FH	LINE PERCENT OF TOTAL	SHOP MMH/FH	SHOP PERCENT OF TOTAL	TOTAL MMH/FH	TOTAL PERCENT OF TOTAL
AIRFRAME	11	3.5	4.3	0.6	0.7	4.1	5.0
LANDING GEAR	13	2.6	3.2	0.4	0.4	3.0	3.6
FLIGHT CONTROL	14	3.2	3.9	0.1	0.2	3.4	4.1
ESCAPE CAPSULE	16	1.7	2.1	0.0	0.0	1.8	2.1
TURBO JET POWER PLANT	23	7.3	8.9	2.3	2.8	9.6	11.7
AIR CONDITION,PRESSURE	41	0.5	0.6	0.0	0.0	0.5	0.7
ELECTRICAL POWER SUPPLY	42	0.4	0.5	0.3	0.4	0.7	0.9
LIGHTING SYSTEM	44	0.1	0.2	0.0	0.0	0.1	0.2
PNEUDRAULIC POWER SUPPLY	45	0.9	1.1	0.0	0.1	1.0	1.2

TABLE VII (Continued)
MAINTENANCE MAN-HOURS PER FLYING HOUR BY WORK UNIT CC
(NON-SUPPORT GENERAL MAINTENANCE)
NOVEMBER 1968 THRU OCTOBER 1969

TITLE	WUC	LINE MMH/FH	LINE PERCENT OF TOTAL	SHOP MMH/FH	SHOP PERCENT OF TOTAL	TOTAL MMH/FH	TOTAL PERCENT OF TOTAL
FUEL SYSTEM	46	3.0	3.6	0.0	0.1	3.0	3.7
OXYGEN SYSTEM	47	0.1	0.1	0.0	0.0	0.1	0.1
MISCELLANEOUS UTILITIES	49	0.1	0.1	0.0	0.0	0.1	0.1
INSTRUMENTS	51	0.4	0.5	0.6	0.7	1.0	1.2
AUTOPILOT	52	1.5	1.8	1.7	2.0	3.2	3.9
MALFUNCTION ANALYSIS	55	0.	0.	0.	0.	0.	0.
HF COMMUNICATIONS	61	0.0	0.0	0.0	0.0	0.0	0.0
UHF COMMUNICATIONS	63	0.1	0.1	0.2	0.2	0.2	0.3
INTERPHONE	64	0.0	0.0	0.0	0.0	0.1	0.1
IFF/SIF	65	0.1	0.1	0.1	0.1	0.2	0.2

TABLE VII (Concluded)
MAINTENANCE MAN-HOURS PER FLYING HOUR BY WORK UNIT CODE
(NON-SUPPORT GENERAL MAINTENANCE)
NOVEMBER 1968 THRU OCTOBER 1969

TITLE	WUC	LINE MMH/FH	LINE PERCENT OF TOTAL	SHOP MMH/FH	SHOP PERCENT OF TOTAL	TOTAL MMH/FH	TOTAL PERCENT OF TOTAL
MISC COMM EQUIPMENT	69	0.0	0.0	0.	0.	0.0	0.0
RADIO NAVIGATION	71	0.1	0.1	0.3	0.4	0.4	0.5
BOMBING NAVIGATION	73	2.0	2.4	4.8	5.9	6.8	8.3
FIRE CONTROL	74	0.6	0.7	0.1	0.2	0.7	0.9
WEAPONS DELIVERY	75	1.0	1.2	0.2	0.3	1.2	1.5
ELECTRONIC COUNTERMEASUR	76	0.3	0.3	0.1	0.2	0.4	0.5
ECM EQUIPMENT	86	0.	0.	0.	0.	0.	0.
PERSONNEL EQUIPMENT	96	0.0	0.1	0.0	0.0	0.1	0.1
EXPLOSIVE DEVICES	97	1.5	1.9	0.	0.	1.5	1.9
TOTALS FOR NONSUPPORT GENERAL		31.3	38.1	12.1	14.7	43.5	52.8
F111A AIRCRAFT TOTALS		51.4		30.9		82.3	

Table VIII

COMPARISON BETWEEN MEASURED AND CONTRACTOR PREDICTED MAN-HOUR EXPENDITURES

Subsystem or Maintenance Task	Contractor Predicted MMH/FH	Measured MMH/FH	Difference	Comment
Ground Handling and Service	3.6	7.8	+4.2	A large percentage of the difference between predicted and measured MMH/FH was accounted for by the large amount of handling required in the test environment. Two examples that caused excessive handling were that anytime an engine needed to be run up or the fuel system needed maintenance, the aircraft had to be moved a considerable distance to the trim pad or fuel cell.
Aircraft Cleaning	0.1	0.4	+0.3	- - -
Look Phase of Inspection	3.5	14.6	+11.1	A more realistic predicted figure would be approximately 6 MMH/FH. The remainder of the difference can be accounted for by the extensive inspection requirements of Category II testing.
Special Inspections	0.4	3.4	+3.0	The difference was accounted for by peculiar requirements of Category II testing and base environment.
Aircraft and Engine Storage	0.0	0.1	+0.1	- - -
Ground Safety	0.3	0.0	-0.3	- - -
Preparation of Aircraft Records	0.1	0.1	0.0	Met prediction.
Special Weapons Handling	0.9	0.0	-0.9	No special weapons handling was recorded.
Shop Support General	---	12.3	---	These maintenance tasks were not included in contractor predictions, but includes such important taks as wheel and tire buildup and teardown.
Airframe	3.9	4.1	+0.2	- - -
Landing Gear	0.4	3.0	+2.6	The mean time between discrepancies for this subsystem was low at 43.1 hours between in-flight write-ups. This low mean time, combined with the mean time-to-repair of 11 man-hours, accounted for the difference.
Flight Control	1.4	3.4	+2.0	The low mean time between discrepancies of 14.4 hours between in-flight write-ups combined with a mean time-to-repair of 15.1 man-hours account for the difference.
Escape Capsule	0.2	1.8	+1.6	This difference was accounted for by a relatively high mean time-to-fix of 15.1 man-hours while the maximum man-hours required per malfunction were 34.8.
Turbo-Jet Power Plant	5.2	9.6	+4.4	The mean time between discrepancies for this subsystem was low at 9.2 hours between in-flight write-ups. Combined with a mean time-to-fix of 13.9 man-hours accounts for the difference.
Air Conditioning Pressure	0.5	0.5	0.0	Met prediction.
Electrical Power Supply	0.2	0.7	+0.5	The insignificant difference could be accounted for by the relatively high mean time between discrepancy of of 119 hours between in-flight write-ups.
Lighting System	0.1	0.1	0.0	Met prediction.
Hydraulic and Pneudraulic Power Supply	0.5	1.0	+0.5	---
Fuel System	0.3	3.0	+2.7	The majority of the difference was attributed to larger number of fuel leaks and fuel probe problems encountered. This was demonstrated by the low mean time between in-flight write-ups of 24 hours and high mean man-hours-to-fix of 18.7 hours.
Oxygen System	0.1	0.1	0.0	Met prediction.
Miscellaneous Utilities	0.1	0.1	0.0	Met prediction.
Instruments	1.0	1.0	0.0	Met prediction (GFAE).
Autopilot	1.3	3.2	+1.9	This sytem had a low MTBD of 22.6 hours, a high mean time-to-fix of 23.3 hours, and maximum man-hours of 58.0 hours to account for the difference.
Malfunction Analysis	0.1	---	---	No data recorded.
HF Communications	1.9	0.0	-1.9	This system was not used during this period.

Table VIII (Concluded)

Subsystem or Maintenance Task	Contractor Predicted MMH/FH	Measured MMH/FH	Difference	Comment
UHF Communications	0.2	0.2	0.0	Met prediction.
Interphone	0.1	0.1	0.0	Met prediction.
IFF/SIF	0.2	0.2	0.0	Met prediction.
Radio Navigation	0.4	0.4	0.0	Met prediction.
Bombing Navigation	3.1	6.8	+3.7	The MTBD of the INS, attack radar, radar altimeter, and TFR are 15.8, 7.7, 28.2, and 10.6 hours, respectively. The respective mean time-to-fix man-hours are 26.7, 18.0, 7.1, and 31.8 hours. The combination of these two account for the large difference.
Fire Control	0.1	0.7	+0.6	All maintenance was expended against the LCOS. The bomb timer did not have any in-flight write-ups. The LCOS had mean time-to-repair man-hours of 26.5 hours and maximum repair of 40 hours.
Weapons Delivery	0.5	1.2	+0.7	This difference could be accounted for the small data size and pre-production equipment.
Electronic Countermeasures	1.6	0.4	-1.2	Insignificant utilization of equipment to make a decision.

Table IX

DISTRIBUTION OF MAINTENANCE EVENTS - LINE ACTIVE HOURS

Subsystem	Non-Parametric Statistics: Mean	Std Dev	Median	M_{max}	Best Fit Distribution Parameters: Log Normal μ	Log Normal σ^2	Exponential θ	Weibull θ_1	Weibull θ_2
Airframe	3.16	4.05	1.30	8.00	← NO FIT →				
Landing Gear	3.66	6.46	1.20	7.50	← NO FIT →				
Flight Control	3.60	3.48	2.40	8.10	0.83	1.01			
Escape Capsule	3.95	5.08	1.70	8.50	0.86	1.03			
Turbo Jet Power Plan	4.88	6.60	2.00	11.80	← NO FIT →				
Air Conditioning, Press	2.71	4.31	1.20	3.50	0.42	1.04			
Electrical Power Supply	2.14	1.53	1.70	3.90				1.398	0.304
Lighting System	1.20	0.88	0.70	2.00	-0.06	0.52			
Hydraulics and Pneumatics	3.23	4.62	1.30	8.20	0.50	1.29			
Fuel Systems	5.43	6.41	3.50	10.50			0.182		
Oxygen System	1.37	1.98	0.70	3.50				0.709	0.935
Miscellaneous Utilities	1.93	2.21	0.90	3.20				0.870	0.601
Instruments	2.20	3.50	1.20	4.20	← NO FIT →				
*Autopilot	4.04	3.34	3.25	7.90				1.206	0.172
*Air Data System	2.59	1.73	2.00	4.00				1.505	0.205
HF Communications	0.87	0.53	0.80	1.00			0.857		
UHF Communications	1.39	0.75	1.00	2.00				1.873	0.434
Interphone	1.60	1.21	1.00	3.00			0.547		
IFF	2.03	1.01	1.50	3.50	0.60	0.25			
Radio Navigation	1.85	1.10	1.00	3.00	0.45	0.36			
*Inert Bomb Navigation	3.95	5.04	3.10	5.30	1.07	0.49			
*Attack Radar	3.28	2.49	2.25	6.20				1.316	0.189
Radar Altimeter	1.60	1.01	0.90	2.75	← NO FIT →				
*TFR	4.47	4.65	2.90	11.00	1.09	0.86			
Fire Control	4.49	5.83	2.50	8.00			0.197		
*LCOS	6.60	7.59	3.25	8.90	1.52	0.67			
Weapon Delivery	4.19	5.45	2.00	7.80				0.776	0.369

*These subsystems have plots of best fit distribution in appendix I.

Table X

DISTRIBUTION OF MAINTENANCE EVENTS - SHOP ACTIVE HOURS

Subsystem	Non-Parametric Statistics: Mean	Std Dev	Median	M_{max}	Best Fit Distribution Parameters: Log Normal μ	Log Normal σ^2	Exponential θ	Weibull θ_1	Weibull θ_2
Airframe	7.72	8.10	6.00	18.00				0.949	0.147
Landing Gear	2.02	2.93	1.00	2.80	←		NO FIT		→
Flight Control	3.35	4.48	1.00	8.00	0.58	1.22			
Escape Capsule	2.17	2.57	1.00	4.20	←		NO FIT		→
Turbo Jet Power Plan	3.36	9.86	1.00	6.70	←		NO FIT		→
Air Conditioning, Press	0.97	1.24	0.40	1.60				0.793	0.132
Electrical Power Supply	3.64	7.28	1.20	6.50	0.48	1.27			
Lighting System	1.17	0.28	0.75	1.30			0.571		
Hydraulics and Pneumatics	3.04	3.22	1.00	6.00	0.47	1.74			
Fuel Systems	2.96	3.84	0.80	8.00	-0.16	2.16			
Oxygen System	1.00	0.25	0.60	1.30	-0.10	0.31			
Miscellaneous Utilities		Insufficient Data			←		NO FIT		→
Instruments	3.73	8.84	2.80	8.00				1.254	0.175
*Autopilot	6.31	8.09	3.10	14.50	1.29	1.08			
*Air Data System	8.96	5.83	6.70	12.50				1.553	0.028
HF Communications		Insufficient Data							
UHF Communications	6.70	6.40	3.20	14.70				1.044	0.135
Interphone	2.44	0.98	1.70	3.00	0.83	0.15			
IFF	3.34	2.73	2.10	4.00			0.273		
Radio Navigation	7.07	8.22	3.50	13.00	1.42	1.28			
*Inert Bomb Navigation	9.85	7.80	8.10	20.50				1.260	0.051
*Attack Radar	7.41	6.73	5.90	15.20				1.096	0.107
*Radar Altimeter	3.08	2.45	2.30	7.30	0.84	0.69			
*TFR	12.20	8.94	10.70	26.25			0.079		
Fire Control	4.50	3.93	2.50	8.50	1.11	1.05			
*LCOS	5.07	3.86	2.80	9.00			0.169		
Weapon Delivery	16.67	8.50	7.00	20.00			0.040		

*These subsystems have plots of best fit distribution in appendix I .

Table XI

DISTRIBUTION OF MAINTENANCE EVENTS - TOTAL ACTIVE HOURS

Subsystem	Non-Parametric Statistics: Mean	Std Dev	Median	M_{max}	Best Fit Distribution Parameters: Log Normal μ	Log Normal σ^2	Exponential θ	Weibull θ_1	Weibull θ_2
Airframe	4.04	5.59	1.60	8.70	←		NO FIT		→
Landing Gear	3.94	6.63	1.70	8.00	←		NO FIT		→
Flight Control	3.97	4.16	2.70	8.30	←		NO FIT		→
Escape Capsule	4.02	5.05	1.70	8.50	0.90	1.02			
Turbo Jet Power Plan	4.17	9.23	1.30	8.50	←		NO FIT		→
Air Conditioning, Press	2.48	4.07	0.90	3.50	0.31	1.06			
Electrical Power Supply	3.02	5.24	1.70	4.00	0.55	0.96			
Lighting System	1.30	0.89	0.70	2.20	0.02	0.54			
Hydraulics and Pneumatics	3.40	4.62	1.40	8.20	0.55	1.37			
Fuel Systems	5.38	6.54	3.50	10.50			0.184		
Oxygen System	1.39	3.54	0.82	1.50	-0.16	0.89			
Miscellaneous Utilities	2.10	2.32	0.90	4.50				0.903	0.534
Instruments	3.85	3.92	2.20	8.70	0.90	0.91			
*Autopilot	7.45	9.41	4.00	19.10	1.44	1.14			
*Air Data System	6.61	6.46	3.30	13.70	1.34	1.44			
HF Communications	2.24	3.08	1.00	3.00	0.12	1.72			
UHF Communications	4.51	5.20	2.00	8.00	0.92	1.30			
Interphone	2.27	1.82	1.70	2.90	0.57	0.57			
IFF	3.59	3.37	2.10	8.70	0.97	0.57			
Radio Navigation	7.56	8.40	4.00	13.00				0.899	0.169
*Inert Bomb Navigation	9.99	8.91	7.75	21.70			0.098		
*Attack Radar	6.66	7.21	3.90	16.30			0.148		
*Radar Altimeter	3.06	2.62	2.10	6.00	0.82	0.61			
*TFR	11.22	11.00	9.00	30.70	1.95	1.56			
Fire Control	5.62	7.06	2.20	12.00	1.08	1.49			
*LCOS	8.63	9.72	3.75	20.00				0.887	0.156
Weapon Delivery	5.58	8.03	2.00	8.50	0.87	1.84			

*These subsystems have plots of best fit distribution in appendix I .

Table XII

DISTRIBUTION OF MAINTENANCE EVENTS - LINE MANHOURS

Subsystem	Non-Parametric Statistics: Mean	Std Dev	Median	M_{max}	Best Fit Distribution Parameters: Log Normal μ	σ^2	Exponential θ	Weibull θ_1	θ_2
Airframe	7.08	12.28	2.80	18.50	←		NO FIT		→
Landing Gear	11.61	26.23	3.00	26.00	1.40	1.90			
Flight Control	11.88	15.83	5.90	29.00	1.72	1.76			
Escape Capsule	15.21	22.71	7.50	34.80	2.02	1.57			
Turbo Jet Power Plan	18.30	28.40	5.00	51.30	1.80	2.56			
Air Conditioning, Press	6.42	10.30	2.90	12.00	1.15	1.53			
Electrical Power Supply	5.12	5.45	3.50	8.50	1.23	0.89			
Lighting System	2.05	2.17	1.00	3.00	0.36	0.69			
Hydraulics and Pneumatics	7.41	11.12	1.50	18.00				0.684	0.303
Fuel Systems	19.41	32.93	8.00	39.00	2.00	2.29			
Oxygen System	3.44	7.73	0.80	8.00	0.20	1.47			
Miscellaneous Utilities	6.80	14.10	2.50	8.50	0.88	2.09			
Instruments	4.36	5.50	1.50	9.00	0.96	0.97			
*Autopilot	13.89	15.30	10.10	25.60			0.071		
*Air Data System	4.74	3.71	3.20	7.50				1.273	0.126
HF Communications	0.92	0.50	0.90	1.70			0.811		
UHF Communications	2.89	2.00	1.30	5.00	0.31	0.61			
Interphone	2.11	2.04	1.00	5.00	0.34	0.92			
IFF	3.88	2.66	3.00	5.50				1.468	0.118
Radio Navigation	3.98	3.37	3.00	6.80			0.232		
*Inert Bomb Navigation	10.54	22.93	5.50	14.40	1.78	0.76			
*Attack Radar	9.63	11.70	4.75	26.00	1.72	1.08			
*Radar Altimeter	3.76	3.13	2.40	7.00	1.00	0.71			
*TFR	10.20	12.11	5.60	19.50	1.85	1.00			
Fire Control	15.32	24.45	6.80	32.00				0.649	0.209
*LCOS	22.88	36.82	10.00	30.00	2.41	1.46			
Weapon Delivery	15.68	31.31	5.00	22.00				0.543	0.303

*These subsystems have plots of best fit distribution in appendix I .

Table XIII

DISTRIBUTION OF MAINTENANCE EVENTS - SHOP MANHOURS

Subsystem	Non-Parametric Statistics: Mean	Std Dev	Median	M_{max}	Best Fit Distribution Parameters: Log Normal μ	σ^2	Exponential θ	Weibull θ_1	θ_2
Airframe	10.74	13.06	7.50	23.00				0.825	0.154
Landing Gear	3.53	6.73	1.80	4.00	←		NO FIT		→
Flight Control	4.94	7.22	1.20	10.00				0.699	0.386
Escape Capsule	2.20	2.56	1.00	1.30				0.862	0.541
Turbo Jet Power Plan	9.76	48.79	0.95	10.00	←		NO FIT		→
Air Conditioning, Press	1.74	2.68	0.60	3.00				0.668	0.835
Electrical Power Supply	16.02	44.79	1.50	26.00	←		NO FIT		→
Lighting System	1.50	0.50	1.20	1.75	0.37	0.12			
Hydraulics and Pneumatics	3.71	3.92	1.00	8.00	0.60	2.01			
Fuel Systems	4.21	5.68	0.80	10.00	0.38	2.44			
Oxygen System	1.67	1.15	0.90	2.50				1.452	0.413
Miscellaneous Utilities		Insufficient Data			←		NO FIT		→
Instruments	8.94	7.10	6.40	17.10			0.109		
*Autopilot	18.13	26.46	8.50	38.50	2.21	1.45			
*Air Data System	28.40	17.14	28.50	46.00				1.682	0.003
HF Communications		Insufficient Data			←		NO FIT		→
UHF Communications	13.43	16.08	4.70	37.00				0.837	0.123
Interphone	5.10	1.27	4.50	8.50	1.61	0.05			
IFF	6.17	4.77	2.60	10.80			0.147		
Radio Navigation	12.51	14.67	6.00	21.50			0.076		
*Inert Bomb Navigation	26.72	25.50	22.40	47.00				1.043	0.032
*Attack Radar	18.80	17.54	12.40	50.00				1.067	0.043
*Radar Altimeter	7.03	6.69	5.80	14.25			0.137		
*TFR	32.97	27.24	26.00	77.00				1.207	0.014
Fire Control	10.69	10.72	5.00	23.70				0.993	0.095
*LCOS	12.14	10.69	5.50	24.00				1.132	0.056
Weapon Delivery	52.00	25.43	33.50	58.00	3.88	0.21			

*These subsystems have plots of best fit distribution in appendix I .

Table XIV

DISTRIBUTION OF MAINTENANCE EVENTS - TOTAL MAN-HOURS

	Non-Parametric Statistics				Best Fit Distribution Parameters				
					Log Normal		Exponential	Weibull	
Subsystem	Mean	Std Dev	Median	T_{max}	-	2	-	1	2
Airframe	8.10	13.38	2.80	22.05	NO FIT				
Landing Gear	11.22	25.42	3.60	25.50	1.41	2.74			
Flight Control	12.12	16.26	6.50	29.00	1.73	1.77			
Escape Capsule	15.11	22.56	7.50	34.20	2.02	1.51			
Turbo Jet Power Plan	13.93	44.19	2.00	34.00	NO FIT				
Air Conditioning, Press	5.81	9.76	2.90	10.50	0.38	1.66			
Electrical Power Supply	10.66	32.08	3.25	13.00				0.943	0.298
Lighting System	2.16	2.15	1.50	3.50	0.42	0.70			
Hydraulics and Pneumatics	7.46	10.91	2.00	18.00				0.699	0.290
Fuel Systems	18.68	32.55	7.80	39.00	1.90	2.46			
Oxygen System	3.35	7.36	1.00	6.60	0.26	1.37			
Miscellaneous Utilities	6.83	13.78	2.00	7.50	0.92	2.35			
Instruments	8.45	9.96	5.00	21.50				0.249	0.176
*Autopilot	23.28	30.93	10.90	58.00	2.46	1.53			
*Air Data System	17.81	19.22	7.50	42.00	2.12	2.15			
HF Communications	5.64	10.55	0.95	12.00	0.45	2.70			
UHF Communications	9.13	12.20	4.50	16.00	1.57	1.34			
Interphone	3.85	3.38	2.50	5.06				1.135	0.205
IFF	6.73	5.30	4.50	12.00	1.61	0.65			
Radio Navigation	13.64	14.75	9.00	21.60				0.936	0.088
*Inert Bomb Navigation	27.01	31.12	20.10	54.00				0.868	0.061
*Attack Radar	18.04	21.37	9.10	45.00	2.18	1.78			
*Radar Altimeter	7.10	6.85	5.50	14.90				1.032	0.131
*TFR	31.75	32.74	14.90	81.00	2.73	2.06			
*Fire Control	16.64	25.85	6.00	40.00				0.664	0.187
*LCOS	26.45	36.97	11.00	40.00	2.55	1.65			
Weapon Delivery	19.94	36.09	5.00	42.00				0.556	0.224

*These subsystems have plots of best fit distribution in appendix I.

Table XV

SUPPORT GENERAL WORK UNIT CODES FOR
TIME TO TURN AROUND

Work Unit Code	Description
01110 01120 01130	Ground Handling
01310	Fuel
01320	Check Oil
01330	Load Oxygen
01340	Air
01360	Check Hydraulic Oil
01370	Armament
01375 01377	Armament, Radio, Radar, IFF
01390	Miscellaneous Service
01410	Tape Change
01430	ECM
01440	Photo
01450	Replace Electronic Spares
01460	AGE
032XX	Postflight Inspection
06XXX 08XXX	Load Ammo, Bombs

Table XVI

TIME TO TURN AROUND
NON-PARAMETRIC STATISTICS

	Mean	Std Dev	Median	M_{max}
Active Hours	5.93	7.23	4.25	12.00
Man-Hours	20.34	27.80	14.67	39.20

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13. ABSTRACT

During Category II testing the F-111A flew 2,019 hours, generating approximately 31,000 reliability and maintainability data records. The majority of Category II tests were flown on preproduction aircraft; however, several production aircraft were also tested. This report covered only the last 22-month period so that the analysis would be more representative of production aircraft. The analysis utilized 1,240 of the flying hours and approximately 18,000 of the data records. The F-111A had a 0.83 probability of mission success during Category II testing versus a contractor specified reliability of 0.85. The 0.83 probability of mission success may be misleading because missions which might have been aborted operationally were considered successes when part of the planned mission test objectives were met. All other avionic subsystems were below the CEI specified MTBF's except for the Countermeasures Receiver Set and Radar Homing and Warning System which had insufficient testing time to determine an MTBF. The measured maintenance man-hours per flying hour for the F-111A during Category II testing was 82.3 hours as compared to the contract specification of 35. The subsystems that failed to meet the contractor's predicted values by a large margin were the same subsystems that had the low reliability figures.

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
F-111A aircraft reliability maintainability mean times between failures lead computing optical sight UHF communications aircraft maintenance						

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